Annual Report
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Northeastern Forest Experiment Station

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A N N U A L R E P O R T

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NORTHEASTERN FOREST EXPERIMENT STATION

OF GENERAL INTEREST

February 1952

The annual report of the Station is intended to give an account of research activities and important research developments during the past year. These activities and results depend on many factors, including personnel, appropriations, cooperation with other agencies and individuals, special jobs, and program emphasis. The most important of these factors are discussed briefly as a matter of general interest to friends of the Station.

There were a number of important changes in personnel during 1951. V. L. Harper, director of the Station since 1945, was called to Washington July 1 to succeed E. I. Kotok as Assistant Chief of the Forest Service, in charge of forest research. James C. Rettie, chief of the Station's Division of Forest Economics, also went to Washington--first as consultant to the President's Materials Policy Commission and later in charge of flood-control surveys. Harry Camp transferred to Missoula, Montana, in forest economics. Ellis

Williams went to Washington, also in forest economics. Chester H. Burnham, Roland Kendall, Thomas Clark, and Lemuel E. Miller are others who left the Station during the year. Ernst J. Schreiner is in the Netherlands on a Fulbright scholarship and will return to his work in genetics here this summer.

The Station welcomed a number of newcomers during the year. Ralph W. Marquis, from the division of Forest Economics in the Washington office, assumed his duties as new director of the Station in July. Norman Tripp, from Missoula, joined the staff in flood-control surveys; and Norman Griswold, from the Birmingham Research Center, took Harry Camp's place in charge of forest survey. Milford Howard, from Region 8, took Burnham's place as leader of the Anthracite Research Center.

In administrative matters the Station encountered more than the usual number of uncertainties and difficulties during the year. The appropriation was not received until almost the middle of October, and then it carried limitations on the amount that could be spent for salaries and on the filling of vacancies. The pay raise, though welcome to all, added to the difficulty of keeping the budget in balance. The research program was maintained in spite of these problems, but some of the extra things we had wanted to do were postponed again.

A number of special jobs came up during the year. One was a Nation-wide reappraisal of the forest-research effort in management, influences, and economics, requested by the House Appropriations Committee (Whitten Report). The Upper Darby staff and personnel at all research centers were called on to gather information about Forest Service research in relation to non-federal research. Information was gathered on non-federal expenditures for research (1) in cooperation with the Forest Service, (2) correlated with the Forest Service program, and (3) independent of the Forest Service.

Special defense projects also called for Station effort. Fred Simmons of the Forest Utilization Service spent most of the year on detail to the Washington Office, working on the equipment-manpower survey being made at the request of the National Production Authority. In cooperation with Forest Products Laboratory technicians, the Station made a survey of wood use in 25 military installations in the Northeast. A special study was made of the veneer industry and sources of supply. And the Station cooperated with the Regional Office in processing applications for accelerated tax amortization and loans for defense purposes.

The Northeastern Forest Research Advisory Council continued its extremely helpful work of advising and assisting the Station in formulating and carrying out its research projects. The Council held its annual meeting at the University of Maine, Orono, in June. At this meeting the Penobscot Experimental Forest, which was purchased for experimental use by nine pulp and paper companies, was formally turned over to the Station for research purposes.

In general the Station's research program continued on the same lines it has followed in the past few years. Within the limits imposed by budget and personnel an effort was made to intensify research in forest influences and to lay the groundwork for future studies of soil-growth and soil-species relations. The problem of timber quality commanded increased attention. Because of the importance of quality to the consumers and industries of the Northeast a brief analysis of the problem is presented in this report.

THE PROBLEM OF TIMBER QUALITY

The Situation Today

For nearly 400 years a continuous stream of wealth has come from the forests of the Northeast. But today this stream is neither as large nor as rich as it once was. Nor are the quantity and quality of the forest products produced today as high as the forest land is capable of producing. In spite of the past centuries of exploitation today's forests continue to produce much select material. But because of these centuries of exploitation the average quality of today's forest is low, and becoming lower.

Recent forest surveys conducted by the Station in Vermont and West Virginia clearly show the deterioration of the forest stand. It is evidenced by a predominance of trees of small size and low utility. In hardwoods, less than one-third of the saw-timber volume is in the top-grade logs that are suitable for veneer, ship timbers, or the economic production of lumber

for fine furniture, for example. In softwoods, it is difficult to find spruce suitable for piano sounding boards, white pine for pattern stock, or even clear wide boards for interior trim. One out of five sawlog-size trees in sawtimber stands is too defective to be merchantable.

There is a rather general tendency to discount the importance of quality and to dismiss lightly the problem presented by forest-stand deterioration. Why worry about quality? Aren't we rapidly approaching the time when all wood will be ground up and made into synthetic boards and plastics? The man on the street as well as the timberland owner asks questions such as these. Processes to make reconstituted wood benefit the economy and are encouraging to forestry, but it is highly doubtful that these products will ever replace standard quality items such as lumber and veneer. Our many wood-using industries still depend on quality timber as their major raw material. The best evidence indicates that they will continue to do so in the foreseeable future.

The forests of the Northeast are not supplying quality material to meet the consumer needs of the area. Large quantities of hardwood lumber and dimension stock are shipped into the region each year to supply our factories, and lumber yards depend heavily on imports of softwood from other regions to meet many construction needs.

The wide range of prices between the highest and lowest lumber grades indicates that the wise forest manager should be able to increase his income significantly by growing good timber instead of just any kind of timber. A poor grade of maple and birch lumber, for example, sells for about $50 per thousand board feet; the best grade brings more than $250 per thousand. The wholesale price of No. 4 common white pine is $80; the price for D selects and better is $200. The high stumpage prices paid for well-located good timber are both an indication of the low state of our quality reserves and an incentive to grow timber of good quality.

The historical background of events leading to the current unsatisfactory forest situation is well known. Centuries of exploitation with operations usually concentrated on the choicest trees of the best species, thousands of forest fires, devastating insect and disease infestations, catastrophic storms--all these factors have left us with forests of low producing capacity in which poor timber predominates.

Forest-management practices in the region have not been adequate to counteract the destructive forces. Cutting practices are still generally poor, especially on the smaller private holdings. The lack of access roads precludes proper harvesting in some areas. Most of the difficulty, however, is due to a lack of progressive forest-management policies.

The situation is by no means hopeless. We still have plenty of forests, and the opportunity to rebuild them. To develop forests that produce more than merely marginal values, however, owners and managers of timberlands must embark on a carefully designed management program. A prime objective of such a program must be the development of fully stocked stands of the best species, properly adjusted to the site, and growing vigorously. Such stands will have greatest resistance to deteriorating agents and under good silvicultural practice will yield the straight, clear trees needed for the highest value products.

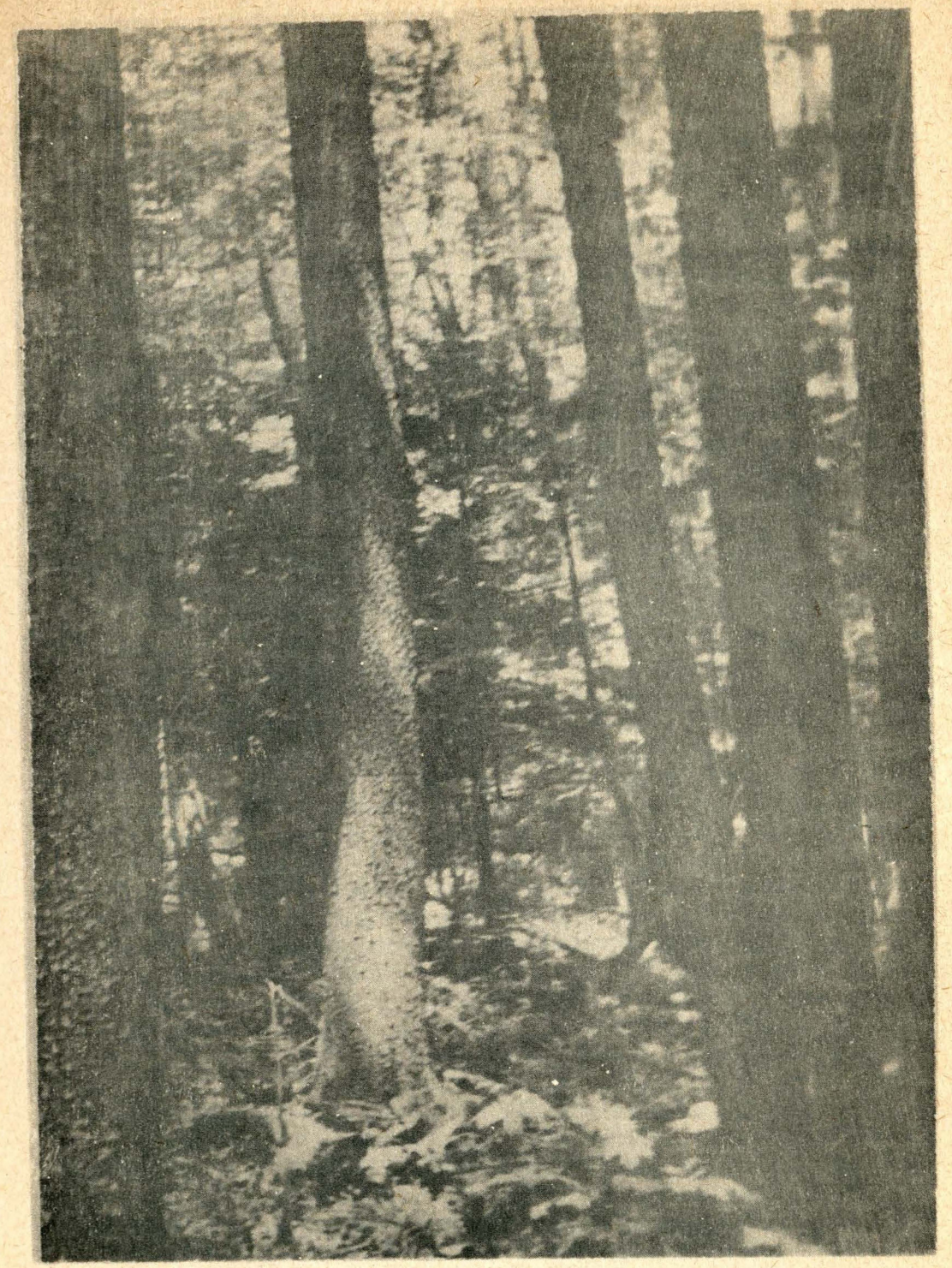
Knowledge needed to produce trees of high quality is being acquired. In recent years great progress has been made in fire protection, while the pathologists, entomologists, and silviculturists are making notable progress in disease and insect control. Research has developed good cutting practices and effective silvicultural measures. The economic conditions under which a high order of forest management can be profitable are becoming understood, and institutional changes to produce these conditions are beginning to be made. But more needs to be known. And what is known needs to be put into practice.

The Problem Of Improving Timber Quality

Improving the quality of the timber in the forests of the Northeast involves many problems--problems in engineering, land management, biology, economics.

There is a difference between converting a small area inadequately stocked with low quality or cull trees to a forest capable of producing a maximum yield of high-quality timber, and converting an entire region to quality production. For the small individual forest the problem is one of applying the best silvicultural and management measures known. But if all the forest land in the region were to be dedicated to producing quality timber, additional problems would arise. The effect on production, employment, and consumption throughout the region would have to be considered.

A low-quality stand typical of many areas in the Northeast. The tree in the center foreground is a defective beech. Note the many poorly formed trees in the stand.



A stand of high-quality black cherry in the Allegheny National Forest. Saw timber like this is becoming scarce. Compare this with the stand shown on the opposite page.

A region-wide transition to quality production presents a real dilemma. On the one side we must recognize that our forests, although containing some trees of fine species, form, size, and vigor, also contain a preponderance of trees that will never produce quality products but which must be removed to make way for better ones--established crop trees or new reproduction. On the other side there is the sobering practical consideration that our wood-using industries cannot be expected to survive on a harvest consisting largely of culls and trees of inferior species. While the lumber mills might survive with such a harvest, cutting box boards, pallet stock, or rough construction lumber, the secondary wood-using industries could not continue. There is a close relationship between the quality of forest raw material and the amount of remanufacture that can be supported.

The problem apparently can be solved only by a compromise. Just as we are now eating into our basic growing stock (the forest survey indicates that our saw-timber cut exceeds saw-timber growth), so we probably must continue to eat into our quality reserves. But, as an offsetting factor, we must evolve and apply a conscious policy of quality betterment. The problem resolves itself primarily into a question of time. How fast can we improve our forest without permanently handicapping our forest industries? Measures that will help to bridge the gap include improved utilization practices under which each piece of the harvested tree is directed to its highest use. They include conscious efforts to reduce wastage of wood both in the forest and in the mills. They involve improved harvesting methods to the end that margins can be captured from operating efficiencies rather than from quality liquidation. They will undoubtedly include continued dependence upon imports from other regions. A program of this sort dynamically carried out by timberland owners would rapidly lead to the retention rather than the destruction of the quality-building elements in our forests, and a reversal of the present dangerous exploitive trend.

The problem of attaining quality goals naturally involves many individual owners, and the problems that would confront them also must be considered. To dedicate his forest land to production for quality, the owner may have to sacrifice immediate income for a greater income in the future or--if he is too old to expect returns for himself--for an estate of greater value. He may have to invest money in improving his forest land. Many owners cannot do this without relief from timber taxes or without sources of cheap long-term credit.

Revisions in some of our economic institutions may be required if the goal is to be reached.

Other problems of equal importance relate to the technical means of improving timber quality. These are problems of management and silviculture and the related arts and sciences, problems of protection against fire and pests, and problems of economics. Solutions must be found for these problems before the goal of timber quality can be approached.

Research Directed To The Problem

Forest-management people have always recognized quality of timber as an essential factor in the forestry equation. However, in the past their approach has often been indirect, with the emphasis on volume rather than quality production. In recent years the importance of timber quality per se has grown, and quality goals have been more sharply defined. As a result the Station has devoted increasing attention to problems of quality.

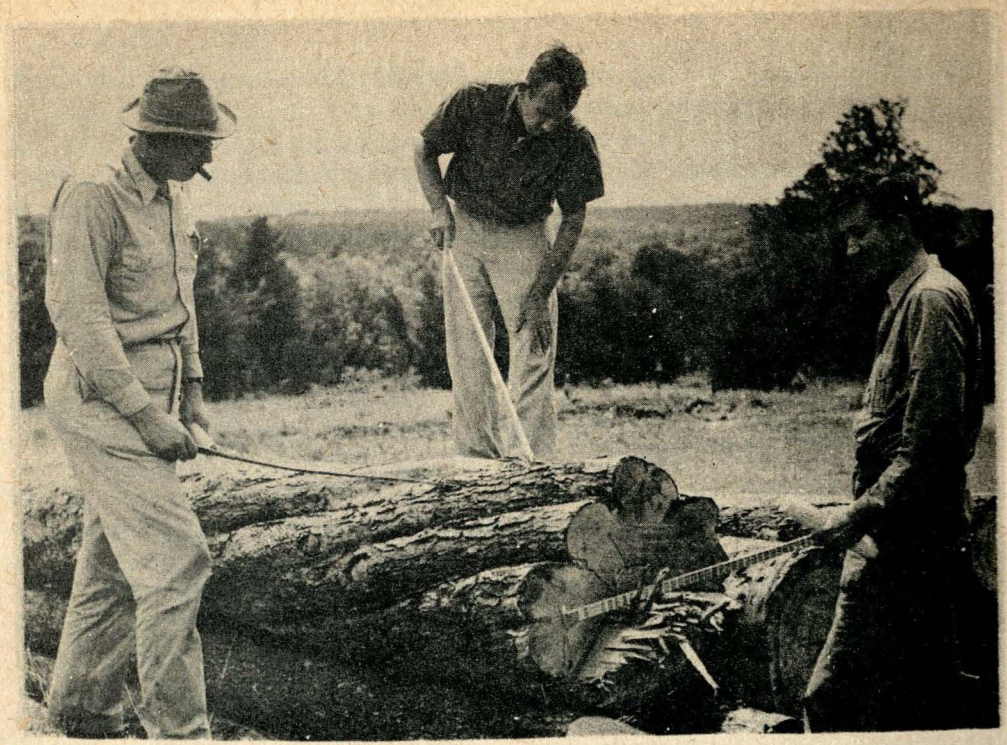
In Forest Survey

The Nation-wide forest survey has the task of finding out how much timber there is, where it is, what it is good for, and how it is being used. For the past several years efforts to appraise timber quality have been intensified. Field crews now grade all logs in trees on sample plots. The quality of the logs in hardwood saw-timber trees is determined by use of the Forest Products Laboratory hardwood log grading system. Softwood trees are graded by a system that was developed by the Northeastern Timber Salvage Administration.

From the survey data now being collected, it is possible to obtain the following important information:

Saw-timber areas classified as to timber quality.

Saw-timber volumes classified according to quality (which is related to basic use possibilities), by species and by tree sizes.



Standard log grades are essential to an efficient forest economy that recognizes the need for quality products. These three foresters, taking part in one of the Station's log-grading schools, are learning how to grade logs. By studying size and length and visible defects such as the spiral grain in this log, they can assign to a log its proper grade.

In Forest Management And Silviculture

In its study of all stages of forest management, from seed to sawlog, the Station is concerned with methods of improving all aspects of the quality of the resulting timber. Prescribed burning is being used in New Jersey, for example, in an experiment to favor establishment of pine seedlings to replace the present low-quality sprout hardwoods. In Pennsylvania mechanical methods (bulldozed furrows) are being tried in an effort to convert scrub oak areas to valuable timber species.

Research in regulation of growing stock, cutting cycles, rotations, and related management measures takes quality as well as volume into account. Cost-return studies consider quality differences as basic to the evaluation of various meth-

By grading his logs, the sawmill operator can estimate rather accurately what proportions of high-quality lumber he can produce. This display, seen at the Vermont State Capitol during the 1951 Vermont Forest Festival, shows graphically the relationship between log grade and lumber yield.

ods and practices. Several studies now under way were designed to find out how low-quality trees can be harvested on a break-even basis, and how trees that will not pay their way to market can be eliminated. Harvest cutting methods are being studied to find out how well-stocked, high-quality stands can be established at minimum cost.

One basic concept now being developed is a method for evaluating site quality from forest cover, soil type, and ground vegetation. This method may give the forester a reliable guide so that he can develop a biologically sound forest by getting the right tree on the right site, and at the same time materially reduce the cost of quality-timber production.

The Station's work in tree breeding, obviously a long-range proposition, is another basic approach to the problem. Our geneticists are trying to breed fast-growing disease-resistant hybrids with good timber qualities. The well-known hybrid poplars are one result of this work.

In Forest Utilization

Most of the Station's work in forest utilization has some bearing, direct or indirect, on the problem of timber quality. We have studied in detail the problems arising from the necessity of removing poor and defective trees from the woods to make room for potential high-quality trees. An obvious way to solve the problem is to find practical uses for the low-grade material present, and this, with the cooperation of the Forest Products Laboratory, we have attempted to do.

Integrated logging is another possibility. This means harvesting trees so that each piece is directed to its highest use. Sometimes this requires special equipment. For example, modern bolter saws are needed for the effective recovery of high-quality dimension stock out of short material that otherwise might be left in the woods. To help timber owners in this field the Station's Forest Utilization Service, which serves as a link between research and industry, has prepared a Northeastern Loggers' Handbook (U.S. Dept. Agr. Handbook 6, 1951). In this and other publications integrated logging and the methods and equipment that make it possible are described.

Another very important utilization problem is that of extending the use of unpopular species. Beech, for example, long considered a problem species and discriminated against

(largely because it is difficult to season), has often been by-passed by the industry. Yet laboratory tests show that for most uses beech is as good as or better than maple or birch. Because research has found ways to season beech efficiently, its fuller use may be expected. To expedite this trend, the Station has been a cooperator on a Northeastern Technical Committee on the Utilization of Beech now working to present, in a series of papers, the best available information about the species. The first paper of the series was published in 1951.

We have taken an even more direct approach to the problem through the use of log grades. To promote the use of the hardwood log grades developed by the U. S. Forest Products Laboratory, the Station has been active in training key foresters and lumbermen in the practical use and advantages of the system. Several publications on the system have also been printed.

These are but a few of the activities in the utilization field that contribute directly to the problem of improving timber quality. There are other important lines of activity toward which attention is directed to the end that forest managers may be able to grow quality wood. One is to reduce waste in the woods, at the sawmill, in the dry kiln, and in the fabricating plant; another is to find new uses for unavoidable wastes and other poor material; a third is to develop new technical information so that all segments of the industry can stretch out the present supply of quality timber and thus ease the drain on the high-quality growing stock that is now being so badly overdrawn.

In Forest Economics

Many forest owners are unaware of the possibilities for profit in growing good trees and often they do not know how to market poor ones; yet the owner or manager of a forest property is the only one who can put forestry into effect on his property.

To help the small forest owner decide if he can increase his income over a long period by growing high-quality trees, the Station has been cooperating with Harvard University in studies of the management alternatives the small forest owner has. A search has been made for small New England forest holdings that have been under management. Records for them should provide basic input-output information on labor, equip-

ment, and materials, and should indicate the value of the various forest-management alternatives.

Marketing is another economic problem, especially for the small owner. Exploratory studies (such as one made of marketing in the Monocacy River watershed) show that considerable basic work is needed in developing grade specifications and marketing services for forest products. The Station's work with primary product specifications is contributing effectively toward meeting this need.

And of course, economic factors such as equitable taxation and the availability of insurance have a direct influence on the small forest owner in determining to what degree he can avail himself of the profit-making possibilities of forestry.

FOREST MANAGEMENT & SILVICULTURE

It is doubtless true in all fields of research--and it seems particularly apparent in forest-management and silvicultural research--that results from a carefully planned program appear, in any one year, to be fragmentary and poorly related. This is inevitable. Some studies were begun more than 10 years ago; some within the last year. Studies differ greatly in duration, in intensity, in emphasis. Some yield results rather slowly, others quickly. Studies differ greatly in the finality of the conclusions that may be drawn at any given time.

In reporting on the work at the Station's 11 active experimental forests and research centers during the past year, we are making no attempt to summarize everything that was done. Rather, we will try to show--at the risk of being incoherent--some of the small advances that characterize steady progress in forest-management and silvicultural research.

The reportable results range widely in both subject matter and importance. Yet each of them, when added to what forest practitioners already know, should contribute in some small way to attaining our goal of better forest management in the Northeast.

Planting Studies

Compared with the job of rehabilitating deteriorated stands, the amount of planting or artificial seeding needed in the Northeast is not large. But here and there are areas where past mistakes in management or land use have been so bad that now we must plant or seed artificially if the land is to become productive again in a reasonable time. On some of these areas past attempts at planting have been failures, or success has been spotty and unpredictable.

One such area is in cut-over and burned lands formerly occupied by spruce in West Virginia. Re-examination of experimental plantings made in 1941 disclosed that some of the erratic results of planting are due to the kind of vegetative cover present; others can be traced to soil conditions.

On sites with dense herbaceous and shrubby vegetation, red pine was more successful than spruce in competing with bracken fern and other herbaceous growth, but red spruce was more successful in competing with overtopping shrubs. Direct seeding failed on these sites.

Where the ground is occupied by young stands of undesirable and brushy hardwoods, planted red spruce should be released the first year after planting for best survival. Whether the release is made the first, second, or third year after planting seems to have little bearing on height growth. Nor, so long as it is 5 feet or larger, does the size of opening made in the overtopping crowns seem to appreciably affect either survival or height growth.

Survival of red spruce has been distinctly better than that of southern balsam fir (Abies Fraseri) when they were planted on the same rocky sites with very thin soil and sparse vegetation. The direct-seeding tests with these two species were not at all encouraging.

Scrub Oak Conversion

Areas occupied by scrub oak in the Pocono section of Pennsylvania are another example of very poor planting sites, a condition traceable to repeated wild fires and other abuses. In the past several years we have found that bulldozing wide,

shallow furrows is a relatively cheap and effective way to prepare such sites for planting.

First- and second-year survival of experimental plantings on these prepared sites has been mentioned in previous annual reports. Although growth in plantations during the first few years is interesting, it is not always a reliable index of species' later development or adaptation to the site. Now, after 4 years (the study was begun in 1948), we are beginning to get more reliable evaluations of species' performance. Some of the important indications and conclusions from the experiment are:

- Burning was worthless as a planting-site preparation on an area burned 3 years previously.

- Scalping was slightly better than no preparation of the planting spots but not as good--in terms of survival and growth--as furrowing with a Killefer plow.

- Over-all plowing was not a success. Survivals (except for black locust) were markedly poorer than in furrows. This held true both for initial plantings and for replantings a year later, when we thought the plowed ground would have become settled into a better planting condition. The trees that did survive grew well.

- Stock of the larger grades generally excels smaller stock in survival and growth.

The species tested in the 1948 plantings seem to line up about as follows:

Red pine is the best all-around species. Its greatest drawback is its slow growth for the first 2 or 3 years, which calls for more thorough site preparation or more release work than for fast-starting species.

Jack pine has proved to be the fastest-starting conifer in these tests. A few specimens exceeded 6 feet in height at the end of the fourth growing season. The ability to overtop the scrub oak quickly makes jack pine a promising species even though it is reputed to do poorly in Pennsylvania after 35 to 40 years of age.

Scotch pine has grown only slightly faster than the slow-starting red pine. And, since it, like jack pine, has a reputation of falling off in vigor at about 40 years, it has little to commend it for scrub oak conversion planting.

European larch has shown great variability. Some trees are now 5 feet tall, but the average height of trees from small planting stock is only about 19 inches. It is the only conifer that responded to plowing as a site preparation. Although a promising species, we believe it should be used with caution until its site requirements are better understood.

Black-locust definitely is unsuited for planting in scrub oak unless favored with superior site preparation and fertilizer applications. On plowed ground, where fertilized, it now averages 10 feet tall, with exceptional specimens 15 feet in height. The ones not fertilized are only 8 feet tall. Unfertilized trees in scalps and furrows are unthrifty and, although tall in comparison with other species, have made poor growth. Mean heights range from 3.5 to 6 feet. So, because of its need for extra cultural measures, black locust is likely to have little use in brush-conversion projects.

White pine averaged only about 16 inches in height and many of the trees are unthrifty. This poor showing, together with its susceptibility to blister rust and weevil damage, renders white pine of little value for replacing scrub oak.

Hybrid poplar showed up moderately well in a small (two clones) side test, but in the main experiment all clones were total failures. There is still the possibility that other clones might do well, but none can be recommended at this time.

During 1951 (in cooperation with the Pennsylvania Department of Forests and Waters) a Seaman rotary tiller was tried out for planting-site preparation in scrub oak. The somewhat ponderous machine, which employs heavy, rotating tines powered by a diesel engine, is designed to chew up vegetation and mix it with the soil. It is drawn by a tractor. It did not perform well in the stony soil and dense scrub where it was tried,

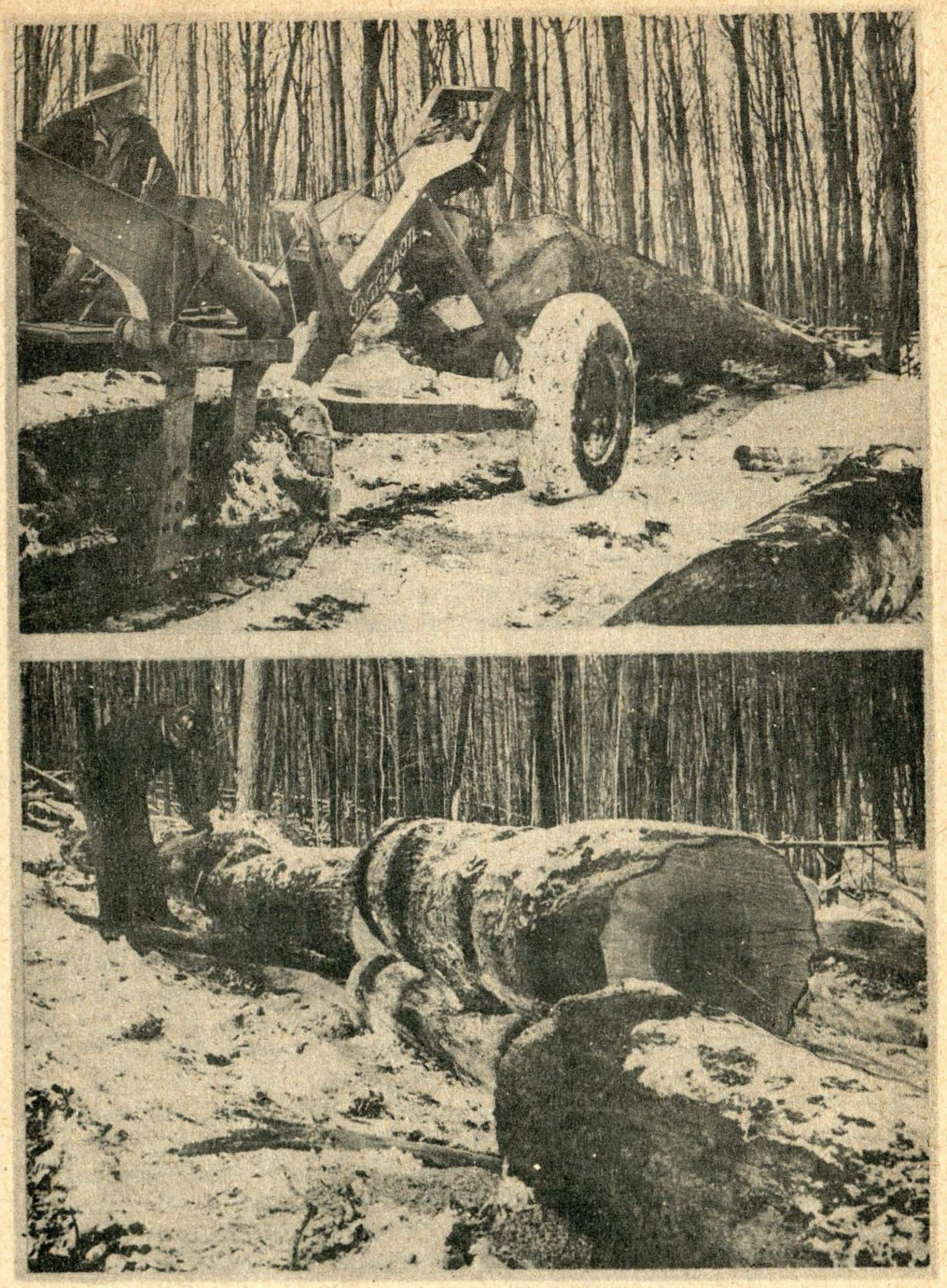
possibly because the owner-operator was reluctant to risk damage at high-speed operation. Even twice over with the machine did not thoroughly break up oak and chestnut stools, and resprouting of these and other species was more vigorous than is desirable. Moreover, the cost of site preparation with this machine is about twice that of bulldozing wide, shallow furrows. Japanese larch, red, pitch, and jack pines, oriental and hybrid chestnuts, and a number of hybrid-poplar clones were planted in the sites prepared this way.

Natural Regeneration

At best, artificial regeneration by planting or direct seeding is expensive or uncertain. Even recent advances in mechanized planting are scarcely enough to offset rapidly rising costs. Measures that assure natural regeneration therefore have an appeal to owners who want to maintain productive forests, particularly if the natural regeneration is less costly.

Normally, landowners have firm preferences about the tree species they want reproduced after harvest cuttings. Industrial owners, of course, usually want what their mills have been using. Owners who grow timber for sale usually want only those species that currently bring highest stumpage prices. The research job, therefore, is to find out the factors and conditions that favor or handicap nearly all the tree species present in the Northeast. Owners do not simplify the job when they ask how desired species can be grown on sites for which other species are better fitted, or how natural ecological progression can be averted simply and cheaply.

Nearly everywhere that pine is found, the ecological succession is to hardwoods as the site quality is built up. And nearly everywhere pine is preferred over the hardwoods. In the pitch pine area of southern New Jersey evidence continues to accumulate that light winter fires can be prescribed to help check hardwoods and provide a favorable seedbed for pine. Fifteenth-year measurements on a series of plots established in 1936 to test different frequencies of burning show that successful pine reproduction is abundant on plots that had been burned three to five times before the overstory was removed in 1946. At that time eight pine seed trees per acre were left. On half-plots that were not cut in 1946, pine reproduction is somewhat less abundant. The most favorable treatment seems to be slightly less frequent burning than one



In this pilot-plant operation at the Fernow Experimental Forest in West Virginia, timber is logged in tree lengths (upper photo). At the landing the trees are bucked up into logs (lower photo). The bucking is done carefully so that each tree will yield the greatest possible volume in high-grade logs.

would judge from the cut-over plots. We believe that two or three prescribed light winter fires at intervals of 2 to 4 years will assure pine regeneration if an adequate seed source is available.

Loblolly pine appears to be another species that fire favors by laying bare the mineral soil and thus preparing a seedbed. But since the mineral soil can also be exposed by mechanical means, a study of the relative effectiveness of the two methods was begun on the Eastern Shore in cooperation with the State of Maryland. Logging a mature stand of old-field loblolly left 35.5 percent of the area covered with slash, 0.1 percent with soil exposed, and an average of 3.8 inches of duff and litter. Where a stump or Ranger Pal fire plow had been dragged around through the stand before logging, the area of bare soil was increased to 3.3 percent, the percentage covered with slash was reduced slightly, and the average depth of duff was 3.1 inches. Broadcast summer burning after logging did not expose quite as much mineral soil but did, of course, almost eliminate the slash and reduced the average duff depth to 1.8 inches. Mechanical treatment before logging, and burning after, should be the most effective combination because it exposed mineral soil on 13.1 percent of the area, left only 2.3 percent occupied by slash, and cut average duff depth to 1.1 inches. Later observations will determine the relative merits of the several treatments in promoting loblolly reproduction.

The value of burning slash after logging is showing up in some plots of Virginia pine that were cut over in 1950. The results are a little confused because the plots are relatively small and are practically surrounded by seed-bearing stands. Nevertheless, where about 15 seed trees per acre were left and slash was burned, 85 percent of the milacres are stocked with pine and average 26 seedlings per milacre. Where no seed trees were left and nothing was done to the slash only 60 percent of the milacres are stocked and seedlings average only 8 per milacre. With a few seed trees but no slash disposal, stocking was intermediate. Because Virginia pine is susceptible to fire damage, the slash was piled and burned, a much more expensive method than broadcast burning. At present, however, it appears that the extra expense is scarcely justified by the modest increase in stocking with pine. Perhaps a cheaper system of burning can be devised.

Fire also shows up as a silvicultural agent in the regeneration of another species, white birch. In the course of

exploratory work on white birch regeneration, the part of the Massabesic Experimental Forest burned in the forest fire of 1947 was studied. White birch was found more abundant where the fire burned with moderate intensity than where it was either more or less intense.

Under some conditions exposure of the forest floor by heavy cutting is followed by disappearance of much of the organic matter, including humus, from the soil. But 15 years after clear-cutting and partial cutting of old-growth northern hardwoods on the Bartlett Experimental Forest, no humus deterioration could be proved. Where even-aged second growth had been cut, however, litter and humus depths were significantly reduced. Average depth of all organic layers (fermentation and humus) decreased from uncut to partially cut to clear-cut areas. (For more details about this study, see section on "Watershed Management.")

The silviculturist's skill in providing proper seedbed conditions and an effective seed source of the desired species, and his timing of cutting to obtain just the desired composition of reproduction may, however, be offset by other factors. In recent years we have reported serious damage by deer to reproduction in several types and localities. This year deer browsed cherry regeneration so severely, on otherwise successful strip cuttings on the Allegheny National Forest, that the future success of this study is doubtful. Fencing to protect experimental plots is expensive but must be used in a number of places if we are to learn anything except that deer can be a nuisance to a silviculturist. No really satisfactory repellant to protect experimental plots has been found so far.

Stand Improvement

With a few exceptions, the make-up of stands in the Northeast is such that there are numerous trees so misshapen, rotten, or otherwise defective, or of species that simply are not salable, that they are not harvestable. We know several ways of removing them and the competition they offer to reproduction and the better trees in the stand; but the search for better and cheaper methods of doing so continues.

During the year our Mountain State Research Center reported that a time study showed poisoning with Ammate in chopped cups at the base of the tree cost two to three times as much as girdling (either single or double hacks). The

difference in cost was least on small trees and greatest on large ones. Computed costs ranged from 5 cents to girdle a 6-inch tree (single hacks) to 39 cents to poison a 30-inch tree. Whether the extra cost of poisoning is justified by quicker kills, less sprouting, or other beneftis remains to be seen.

In the Adirondacks tree-poisoning experiments have been under way for several years. These have included tests of different dosages of several poisons, some of which were only partially effective in killing crowns. Two years after poisoning, trees that originally had 70 percent or more of their crowns killed were gradually dying. Those that had originally lost 50 percent or less of their crowns appear to be recovering slowly.

Getting rid of the poorest elements of a stand is one effective step toward improving its quality and that of the wood being grown. Another is to improve the quality of well-formed trees of desirable species by pruning them so they will produce clear wood. Considering the difference in value between knotty and clear lumber, cost of pruning should be a good investment. The results of a small cost study on the Penobscot Experimental Forest provides an indication of this.

The study was conducted in cooperation with the University of Maine. One hundred thirty spruce trees ranging from 3 to 8 inches d.b.h. were pruned to 18 feet at an average cost of 14.8 cents per tree, including walking time between trees, with labor figured at $1 per hour. Actual pruning time to remove an average of 80 limbs per tree averaged 6 minutes 17 seconds. Some trees had more than 100 branches and the maximum time for them was 8 minutes 39 seconds. Fifty white pines similarly pruned required an average of 2 minutes 42 seconds to remove an average of 44 limbs per tree.

Improvement Through Cutting

But improving the quality of a stand does not always call for an expensive investment. Many times the timber removed can be sold at a price to cover the cost of the improvement or with a little net income to the landowner. This was demonstrated by a pilot operation in the Bartlett Experimental Forest.

The stand was much like thousands of acres of northern hardwood forest today. Only the high-quality sawlogs had been taken in the earlier cuts some decades past. Growth had brought the growing stock up to 2,200 cubic feet per acre, but of this, 40 percent was beech, 24 percent was hard maple and yellow birch, 16 percent was red maple, paper birch, and white ash, and 20 percent was hemlock and spruce. Some 36 percent of the gross hardwood volume was of very low quality; a little less than half of this was suitable for poor local-use lumber only, and the rest was outright cull.

For this first cut the marking rules were relatively simple. They boiled down, essentially, to "cut the mature paper birch, then the other species on the basis of the worst first, leaving a growing stock of about 80 square feet of basal area or 1,600 cubic feet." The general quality of the trees marked was so poor that the entire cut was appraised as pulpwood with a gross stumpage value of $1.70 per cord. A small part of this income may later be used to kill trees the logger simply could not break even on.

The cut really improved the quality component of the growing stock. In hardwoods the proportion of total volume in trees of Grade 3 or better was raised from 64 to 89 percent. Or the change may be expressed in increase in dollar value per 100 cubic feet of volume. Before cutting, 100 cubic feet of the hardwood saw-timber part of the stand could have yielded $21.84 worth of lumber and pulpwood. After cutting, the growing-stock-product value was $25.87 per cunit. The stuff taken out would yield only $17.83 worth of products per cunit. Stated in still another way: the cut removed 50 percent of the hardwood saw-timber volume but only 41 percent of the value. This is radically different from customary cutting practice, yet it makes sense to one who intends to stay in the business of growing good timber as a crop.

Proper Cutting Lessens Storm Damage

Many owners have been afraid to leave good growing stock for fear much of it would be lost to fire, wind, insects, or disease. Fear of windthrow has been particularly prevalent in the spruce-fir region. Outstandingly bad storms do, of course, cause severe damage, but examinations of 3- and 4-year-old partial cuttings made to increase resistance to budworm show that ordinary losses are small. Records on 160 fifth-acre plots indicate that less than one-tenth of a cord per acre was

lost during each of the first 3 or 4 years after the partial cut was made.

Even in severe storms, such as that of November 25, 1950, losses are much less under conservative cutting than under heavier cutting. This holds for both white pine and Virginia pine. In white pine stands the storm took 11 percent of the seed trees where a fair level of cutting practice was used (seed trees left at a spacing of about 40 feet); but only 3 percent where a good level of cutting was practiced (13 percent of the original volume cut).

In Virginia pine stands virtually all the widely spaced seed trees left under a fair level of cutting practice were lost. Under a high-order cutting practice 6 of some 40 seed trees left were lost.

TREE BREEDING

In the spring of 1951 further poplar breeding was undertaken to provide increased disease resistance and to increase the number of clones available for selection work. Good native cottonwoods and the best of the original poplar hybrids were used as parents. The breeding work was done in the greenhouse on cut branches. This was less successful than anticipated, because the branches from many old native cottonwoods failed to root or mature fruit.

Of some 150 combinations tried, about 40 matured catkins. The seed was propagated on very fine sand overlaying sterilized (with Semesan) sifted soil, watered from below. Contrary to usual experience there were almost no losses from damping-off, but cyanide fumigation took its toll. The seedlings are being grown in the nursery at Beltsville. As a corollary to this breeding work, sex was determined on the original poplar hybrids.

A 25-year remeasurement of the original hybrid-poplar planting in Maine showed some decrease in growth rate during the past 5 years. There was little recent mortality among the larger trees that had shown themselves disease-free during the

first 15 and 20 years. But recent mortality was heavy in some families that had earlier showed signs of decadence. Most of the selected trees are now more than 60 feet tall and 12 inches in diameter: the largest is 80 feet tall and 16 inches in diameter. Many of these selected trees occur in parts of the planting where the original 6 x 6 spacing has not been greatly increased by mortality.

A serious difficulty in the culture of poplars is the choice of planting site. We know they grow well on fertile alluvial soils. But few such sites are available. We know they do not grow well on the majority of the dry upland sites, which are available in quantity. So this year we started soils studies to determine just what constitutes the intermediate site that is satisfactory for poplars. Preliminary results point to soil texture as the most important single factor influencing poplar growth. Dr. Schreiner is continuing these studies in Europe.

During the year new poplar clonal tests were established at five of the Station's research centers. For the most part these followed the conventional pattern with plowing before planting and cultivation after planting. Two variations of this were used. At the Anthracite Research Center the ground was prepared by roto-tilling scrub oak land, and no weed control was attempted after planting. At the Beltsville and Hopkins Experimental Forests random mixtures of better-than-average clones were planted on plowed strips; these were cultivated in only one direction.

During 1951, breeding work in genera other than poplar was confined to attempts to mass-produce hybrid seed of combinations already made on a small scale. In the following crosses seed yields per flower and per man-day were large enough to indicate that hybrid seed could be mass-produced economically:

Fraxinus pennsylvanica x velutina

Picea asperata x abies and reciprocal

Picea montigena x asperata

Picea montigena x abies

Pinus banksiana x contorta

Pinus banksiana x murrayana

Pinus banksiana x murraybanksiana

In the maples, white pines, and hard pines of the series Lariciones (Scotch, red, Austrian, etc.) the trials were failures for mass-production purposes, although some hybrids were obtained.

Some techniques for the mass-production of hybrid seed call for the working of unbagged trees and subsequent culling of non-hybrids in the nursery. Study of the growing hybrids shows that this culling could easily be done by a trained man in first-year seedbeds of the following hybrids:

Pinus densiflora x sylvestris

Acer platanoides x cappadocicum

Acer negundo x henryi.

Fortunately each of these three hybrids shows probable hybrid vigor.

Two variations of our usual tree-breeding technique proved moderately successful. Leaving the pollination bags on until seed maturity this year gave very high sets in ash but poor seed sets in pine, though results were just the opposite in 1950. The method is promising but must be used with caution. In spruce, year-old and fresh pollen gave equally high seed sets. Small trials of year-old pollen in pine gave low seed sets.

This year all our birch, ash, maple, pine, and spruce seeds were sown on a thin layer (about 3 times the thickness of the seeds) of nitrogen-treated sawdust overlaying soil, and covered lightly with soil. This proved very successful in the greenhouse and in the nursery. Damping-off losses were low, weed control was easy, and soil moisture remained high. The only difficulties encountered were lack of root penetration when the sawdust layer was too thick and possible root rot (quickly controlled by Fermate) in the nursery in late summer. Over-all survival was much better than with techniques used previously.

FOREST INSECT INVESTIGATIONS

Report from the New Haven Station of the
Division of Forest Insect Investigations;
Bureau of Entomology and Plant Quarantine,
335 Prospect Street, New Haven, Conn.

During 1950 and 1951 the New Haven station of the Division of Forest Insect Investigations has continued its studies and surveys of the spruce budworm, white pine weevil, Matsucoccus scale on red pine, pine sawflies, European pine shoot moth, and beech scale. Some surveys have been made to determine the status of the forest tent caterpillar, balsam woolly aphid, and hemlock looper. Investigations have been made of the newer insecticides and methods and equipment for applying them.

Spruce Budworm

The Adirondack infestation has virtually disappeared. In Maine in 1950 there were some 4 million acres where defoliation on scattered trees could be observed from low-flying aircraft. In 1951 defoliation could be detected on only about 260,000 acres. Intensive study of special plots indicated a sharp reduction in the budworm population, which resulted from the activity of natural control factors, i.e., parasites insectivorous birds, winter mortality, etc. In Maine there appears to be a striking similarity to the pattern of natural control that caused the reduction in budworm population in the Adirondacks.

The threat of an outbreak in Maine still persists, however, because of the possibility of mass flights of moths from the neighboring Canadian provinces of New Brunswick and Quebec, where heavy outbreaks occur.

Airplane-spraying experiments were conducted in a heavy infestation in Quebec in 1951 to obtain additional information on the timing of application, dosage, effect of atomization, and relationship between deposit and mortality. Briefly, these experiments showed that best results are obtained when the majority of the budworm larvae are in the fifth instar; the minimum effective dosage is 1 pound of DDT in 1 gallon of spray

per acre; spray droplets of about 150 microns (mass median diameter) appear to be optimum; deposits of about 0.25 pounds of DDT per acre produce about 95 percent budworm mortality.

White Pine Weevil

Studies are being initiated to determine the effectiveness of natural control factors on white pine weevil populations in several different areas of the Northeast. Studies are also under way to explore the possibility of controlling the weevil through silvicultural practices and the regulation of species mixtures in plantations. These are long-range studies aimed at determining the ecological factors that affect weevil populations.

The ultimate objective is, of course, to determine how white pine may be grown in the Northeast, both in areas of natural reproduction and in reforestation areas, with a minimum of weevil damage.

Considerable progress has been made in controlling the weevil by applying lead arsenate sprays with a knapsack sprayer and by dispersing DDT sprays with a helicopter. Spray is applied in the early spring to kill adult weevils before eggs are laid.

Matsucoccus Scale On Red Pine

An unidentified species of Matsucoccus is causing heavy mortality of red pine in southwestern Connecticut and on Long Island. This scale has resisted all efforts to control it by the use of insecticides. A number of predators attack the scale and there is some indication that low winter temperatures may kill a high percentage of the insects. This insect is potentially a serious threat to red pine.

Pine Sawflies

Several species of sawflies, some native and some introduced, cause severe damage in plantations from time to time. As a control measure, during 1951 an imported virus disease was dispersed in a heavy infestation of Neodiprion sertifer on

red pine in New Jersey. A concentrated culture of the virus, received from Canada, was diluted with water and applied with a knapsack sprayer for control of sawfly larvae. Practically complete control was obtained. It is planned to disperse this virus from aircraft in 1952. This represents a new method for combatting certain forest insects and the subject will be thoroughly investigated.

Consideration is being given to the airplane spraying with DDT in 1952 of a heavy outbreak of Neodiprion lecontei on red pine on the southern division of the Green Mountain National Forest.

European Pine Shoot Moth

A 70-acre area of red pine on the Allegheny National Forest was sprayed with DDT from a helicopter in July 1951 for control of the European pine shoot moth. The results were not satisfactory.

Beech Scale

Studies are being conducted in cooperation with Forest Pathology and the Bartlett Experimental Forest in an effort to control beech scale through the removal of the larger trees in a stand and through the regulation of the density of the stand. Study areas, which have received different degrees of thinning, have been established. Records will be kept of the population build-up of the scale in these areas.

Experiments are also under way on the Bartlett Forest to control the scale by insecticidal applications. Although it would be impractical to try to control the scale in timber stands, it is felt that, where beech is important for aesthetic purposes, direct-control methods might be justified.

Hemlock Looper And Forest Tent Caterpillar

Heavy outbreaks of the hemlock looper have occurred in New Hampshire, Vermont, Massachusetts, Connecticut, and Pennsylvania during the past 2 years. Surveys were conducted by

the New Haven station to determine the degree of infestation on the affected areas. Airplane spraying with DDT is effective in controlling the hemlock looper.

Surveys conducted in cooperation with the New York Conservation Department have revealed an outbreak of the forest tent caterpillar that covers some 100,000 acres in the northern Adirondacks.

Balsam Woolly Aphid

Considerable mortality of balsam fir on the White Mountain National Forest has resulted from attack by the balsam woolly aphid. Plots have been established to obtain more precise information on the economic importance of this insect.

Insecticidal Investigations

Perhaps the most important development in this field has been the construction of an air-blast type of spraying apparatus for use on helicopters. This new device permits the application of large volumes of finely atomized spray when the helicopter is flying at a very slow speed.

FOREST DISEASE INVESTIGATIONS

Report from the Division of Forest Pathology, Bureau of Plant Industry, Soils and Agricultural Engineering, 360 Prospect Street, New Haven, Conn.

During the past two years particular attention has been directed to the disease susceptibility of hybrid-poplar clones, the role of fungi in causing excessive mortality of birch, the rate of deterioration of budworm-killed spruce and balsam fir, the effect of decay upon pulpwood floatability, the possibility of silvicultural control of the scale-Nectria disease of beech, and the preparation of indexes of forest-tree diseases.

Disease Susceptibility Of Hybrid-Poplar Clones

Hybrid-poplar clones selected by Dr. E. J. Schreiner and grown in plots at the Agricultural Research Center, Beltsville, Md., at the Hopkins Memorial Forest, Williamstown, Mass., and at Cheshire, Conn., were inoculated with Septoria musiva, a canker-producing fungus, to test for resistance to the disease. These inoculations are a continuation of the study that was begun in 1947. The testing of 203 clones has now been completed.

A system of rating resistance and susceptibility was devised, based upon host reaction to infection by the fungus. The clones have thus been rated in four classes: resistant, slightly susceptible, moderately susceptible, and highly susecptible. Twenty-five clones have been listed as resistant and 37 as highly susceptible.

Further tests to determine the spread of the disease under natural conditions were made in plantings of hybrid-poplar clones at Beltsville and Williamstown. All clones in these plantings had been previously tested for susceptibility and represented both resistant and susceptible clones. One tree in each of a number of clones was inoculated, the trees being selected so that loci of infection might be scattered throughout the planting.

In the experimental plot at Cheshire, where inoculations with Septoria musiva had been made from 1947 to 1949 on trees of 51 clones, the trees were cut down early in the spring of 1950 and new shoots were allowed to develop from the stumps. On these clones, natural infection by the fungus resulted in abundant spots on the young leaves, and cankers developed on many of the shoots in late June and July. Infection of the stems apparently resulted from the spores produced in furiting bodies on the leaf spots. On the most susceptible clones the stems became girdled by cankers during the summer.

The susceptibility of the clones to leaf-infecting fungi other than Septoria musiva has been under observation. Of these fungi, a species of Marssonina, causing leaf spot, and Septotinia populiperda, causing leaf blotch, are most prevalent. Although premature defoliation of young trees may result from infection by these fungi, the growth of the trees does not seem to be seriously affected. The leaf blotch was found at Beltsville and Cheshire during 1950 and 1951, but was not found at Williamstown. At Cheshire both Septoria musiva and the species of Marssonina were found to overwinter in their respective ascospore stages on fallen leaves, from which early spring infections undoubtedly occurred.

In the spring of 1950 at Cheshire a preliminary series of inoculations was started with Dothichiza populea, which commonly causes dieback and canker of species of poplar, both in the United States and in Europe. No definite evidence of infection was noticeable during the growing season; but in the following spring, when active growth of the trees began, cankers and dieback developed rapidly on most of the clones. A few clones seemed to be only slightly susceptible but further observations during another growing season are necessary to determine this point. At Williamstown the 25 clones that have shown resistance to Septoria musiva are now being tested for their reaction to Dothichiza populea.

Dieback Of Birch

Among the fungi commonly isolated from fresh yellow and paper birch twigs from trees in various stages of decline were species of Fusarium, Gelatinosporium, Melanconis, Melanconium, Phomopsis, and Libertella. As previously reported, these fungi were inoculated into vigorous yellow and paper birch saplings at New Haven, Conn., and Bethlehem, N. H. Final observations, made in July 1951, indicated that none were virulently patho-

genic. One organism, Phomopsis sp., was moderately pathogenic on weakened tissue but was unable to parasitize vigorous tissue.

In 1950 attention was directed to the fungi on the roots of dieback trees or closely associated with them in the soil. Isolations were made from material collected on 10 plots in Maine, with a special technique devised to isolate Phytophthora cinnamomi from the soil. This organism, common in the Southeast but unreported from the Northeast, had been reported in nurseries from Middle Atlantic States as a soil pathogen of birch seedlings. In Maine it was not discovered in the upper 10 inches of soil, nor was it present in root tissue. Among the fungi most frequently isolated from roots was an unknown organism, possibly a species of Cylindrocarpon. Closely associated with birch roots is another unknown fungus that produces an abundance of fine, dark, branched rhizomorphs. This may be a mycorrhizal fungus. No evidence of parasitism has been observed, nor has it been possible to secure this fungus in pure culture.

Of the 121 birch survey plots established in 1949 (in cooperation with the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine), 50 were re-examined in 1950 and 17 additional plots were established, making a total of 138 plots well scattered over Maine, New Hampshire, Vermont, and New York. Fifty more plots were re-examined in 1951. The data taken indicate that birch condition is still declining but that the rate of decline is lessening appreciably.

Deterioration Of Budworm-Killed Trees

As previously reported, studies of the rate of deterioration of budworm-killed spruce and balsam fir were started in Ontario, Canada, in 1947 and 1948, in cooperation with Canadian investigators. Twenty-seven ¼-acre plots in areas where mortality was heavy were clear-cut and 1,446 balsam firs, 258 black spruce, and 205 white spruce were dissected.

Analysis of the data indicates that balsam fir must be salvaged within 2 years after death but that black and white spruce may be salvageable for 5 years after death. The proportion of balsam fir in the stand is the important factor in determining the maximum period after mortality when salvage is economically feasible. Approximate volume losses from decay in balsam fir for trees dead 1, 2, 3, 4, and 5 or more years

were 15, 47, 48, 85, and 95 percent, respectively. Analagous losses for black and white spruce combined were 10, 20, 22, 25, and 75 percent, respectively.

Decay In Relation To Floatability

In this study 1,243 four-foot bolts are now under test, of which 1,022 are balsam fir and 221 are red spruce. Variables recorded for each bolt are species, position on tree (butt, mid-bole, or top), number and size of knots, proportion of sapwood to heartwood, total volume, green weight, weight after seasoning (or at time of immersion), rough or peeled, and kind, stage, and amount of rot. The test is being made in northern Maine in cooperation with the Hollingsworth and Whitney Co. The bolts are boomed in dead water and their floating heights are checked periodically.

By October 1951, 149 bolts (15 percent) had sunk and an additional 39 bolts (3 percent) were "bobbing." Some bolts sank shortly after immersion but others floated for 2 years or more. Preliminary analysis indicates that rot in butt bolts does not predispose them to sinkage but that rot in upper mid-bole and top bolts does, especially if they are not well seasoned. Sound green top bolts may sink quickly, particularly those from balsam fir trees.

Silvicultural Control Of Scale-Nectria

Earlier observations indicated a direct relationship between the build-up of scale and Nectria on beech and tree vigor, stand density and composition. To test the validity of these observations, 40 tenth-acre study plots have been established on the Bartlett Experimental Forest and the White Mountain National Forest (in cooperation with the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine; The White Mountain National Forest; and the Bartlett Experimental Forest).

Fifteen plots are in a fairly dense old-growth beech stand where the disease is already serious and conditions apparently are excellent for its continued intensification. Twenty plots are in a stand where the disease is common but where a selective logging operation in 1947 removed all merchantable trees 15 inches d.b.h. and over. Ten of these plots

are in a portion of the stand where, in addition to the logging, all unsound or low-vigor beech trees, regardless of size, were removed. Five plots are in a similar stand, logged in the same way in 1947, where the disease is just getting started. Before these five plots were established, all residual unmerchantable trees of all species, 15 inches d.b.h. and over, and all unsound or low-vigor beech trees, regardless of size, were girdled. These 40 plots will be examined periodically to follow the course of the disease.

On the Bartlett Experimental Forest five 5-acre compartments containing a high percentage of all-age beech have been treated as follows and will be examined periodically to determine the effect of the treatment on the build-up of the scale-Nectria disease. One is undisturbed, one thinned lightly, one thinned moderately, one thinned heavily, and one thinned heavily with all underbrush removed and kept out for the duration of the study. In the thinnings no beech trees were removed unless necessary to obtain the required density.

Forest-Tree-Disease Indexes

Since his retirement in 1948, Dr. Perley Spaulding has been appointed annuitant collaborator to continue his indexing of forest-tree diseases in North America. In addition, he has accepted the assignment of preparing an index of the diseases of North American forest trees planted abroad and of the diseases of foreign forest trees, which if introduced to this continent, would be a potentially serious threat to North American trees. Botanical publications from all countries are being combed for references to tree diseases and the data are summarized and filed for ready reference. The domestic section now contains approximately 250,000 items and the foreign section approximately 50,000 items.

WATERSHED MANAGEMENT

A Division of Forest Influences Research was established at the Station during the past year. This reflects the ever-increasing recognition of the importance of watershed management to the supply, control, and utilization of water, and the relationship of the water resource to the forest resource.

Although the total water supply in the Northeast is more than sufficient for any foreseeable needs, water yields do not always occur when or where they are needed. Many streams discharge large quantities of water into the ocean during the spring, then shrink to inadequate flows during late summer and fall.

Besides producing water, most of the watershed lands outside the agricultural and urban areas must serve a variety of uses. They must provide timber and other wood products, recreational opportunities, fish and wildlife. Good watershed management provides for the proper integration of these multiple uses in such a manner as to conserve and improve the water resource. Forest-influences research is needed in the Northeast to provide the knowledge upon which sound watershed-management plans may be based.

Although at present most of the Station's forest influences work is concentrated at the Delaware Basin and Mountain State Research Centers, some work is being carried on at the Anthracite, Northern Hardwoods, Adirondack, and Penobscot Research Centers. Some of these studies are of a long-term nature and cannot be expected to yield final results for a number of years, but much information is becoming available about individual factors and conditions that affect water supply, quality, and rate of yield.

Soil-Freezing Studies

Soil freezing has been recognized for a number of years as an important factor in watershed management. Frozen soil influences runoff during periods of rainfall or melting snow. Four different types of soil freezing occur: concrete, honeycomb, stalactite, and granular. Research done elsewhere has demonstrated that, of the four types, concrete frost is the only

one that is impervious to water. Therefore it is of importance to know under what conditions concrete frost is most likely to occur during freezing weather.

During the winter of 1950-51 observations of soil freezing were made at periodic intervals on a number of plots in Maine, New Hampshire, Massachusetts, northern New York, southern New York, and northeastern Pennsylvania. The plots these observations were made on were selected to represent a variety of land uses and conditions.

Analysis of data from these studies demonstrates that a great range of occurrence of concrete frost may exist even on plots covered with vegetation. The type of vegetation, its age and density, and the condition of the forest floor are all factors that influence the occurrence of concrete frost. The following examples demonstrate the effect of some of these factors upon occurrence of concrete frost.

On the Hopkins Experimental Forest in northwestern Massachusetts, abandoned agricultural lands that have good stands of natural reproduction of tree species developed concrete frost to only one-half the depth of that occurring on adjacent abandoned lands that have no natural reproduction. In the spring the concrete frost was entirely gone from those areas having good natural reproduction 10 days before it disappeared on those areas having no reproduction.

Near Paul Smiths Experimental Forest in northern New York, coniferous plantations about 20 years old developed some 50 percent more concrete frost than coniferous plantations 30 to 35 years old. The concrete frost disappeared from the older plantation about 1 week earlier than it did in the younger planting.

In southern New York, near Deposit, well-stocked coniferous saw-timber stands developed from three to four times as much concrete frost as well-stocked hardwood saw-timber stands. Coniferous pole stands and hardwood pole stands showed approximately the same relationship. All concrete frost was gone from the hardwood stands approximately 3 weeks before it disappeared in the coniferous stands.

The effect of fire upon the occurrence of concrete frost is demonstrated by observations made in the vicinity of the Paul Smiths Experimental Forest. Two well-stocked coniferous saw-timber stands were compared. One stand was comparatively undisturbed, while the second had been subjected to a recent fire that consumed the litter and humus but did not destroy the

tree canopy. The undisturbed stand developed only about one-fourth as much concrete frost as the burned stand. Concrete frost disappeared from the undisturbed stand about $2\frac{1}{2}$ weeks sooner than in the area that was burned.

A comparison of three hardwood saw-timber stands near Paul Smiths Experimentsl Forest, with different degrees of disturbance of the forest floor, showed striking differences in occurrence of concrete frost. One stand was comparatively undisturbed, the second had been lightly logged, and the third had been rather heavily grazed. The logged stand developed approximately twice as much concrete frost as the undisturbed stand, while the grazed stand developed seven or eight times as much concrete frost as the undisturbed area. Concrete frost disappeared from the undisturbed stand about 3 weeks before that in the logged stand, and about 6 weeks before that in the grazed area.

Another striking illustration of the effect of grazing in hardwood stands is shown by measurements taken near the Penobscot Experimental Forest in Maine. Here a well-stocked hardwood saw-timber stand that had been heavily grazed developed from two to three times as much concrete frost as a nearby poorly stocked hardwood saw-timber stand that had not been grazed. Concrete frost disappeared in the spring from the ungrazed stand about $3\frac{1}{2}$ weeks sooner than in the grazed area.

These examples may be summarized in the following findings:

- The formation of concrete frost is impeded by the development of natural tree reproduction on abandoned agricultural lands.
- Older stands retard the formation of concrete frost more than young stands.
- Hardwood stands have less concrete frost than comparable coniferous stands.
- Disturbance of the forest floor is conducive to the formation of concrete frost. The amount of concrete frost is directly related to the amount of disturbance of the forest floor.

During the spring months large quantities of water are released upon watershed lands by rain and melting snow. In the interests of water conservation and control, it is highly

important that as much as possible of this water enter the ground rather than run off in flood flows. It is evident from soil-freezing observations that certain forest conditions should be avoided if the maximum opportunity for water infiltration is to be maintained. Those land uses and conditions that have the least concrete frost for the shortest period of time are the most desirable for purposes of regulating streamflow.

Humus Deterioration

Measurements made by the Station during flood-control surveys have indicated the great importance of litter and humus in maintaining a high detention storage in a watershed. A high detention storage is an important factor in the reduction of rapid runoff during storm periods.

Studies made on the Bartlett Experimental Forest in New Hampshire during the past year show that method of timber cutting can significantly affect litter and humus depths. Six plots of approximately 10 acres each were selected. Plot 2 was covered with a typical northern hardwood stand that had been uncut since about 1850-55, at which time it had received a partial selective cut. Plot 2 had a stand similar to Plot 1 until 1935, at which time the area was clear-cut and mowed. Plot 3 was also similar to Plot 1 until 1934, at which time it received an individual tree-selection-type cutting, during which about 30 percent of the volume was removed. These first three plots were side by side. The other three plots were grouped less than ½ mile away. Plot 4 was covered with a typical northern hardwood stand which had been uncut since about 1850-55, but at that time the stand was clear-cut. The stand now is uniform even-aged. Plot 5 was similar to Plot 4 until 1939, at which time it was clear-cut and mowed. At the time of clear-cutting there was no advanced reproduction on this area. Plot 6 was also similar to Plot 4 until 1937, at which time it received a 40 percent thinning.

Twenty measurements of litter and humus depths were made on each plot. Comparison of litter and humus depths for Plots 2 and 3 with those for Plot 1 indicates that cutting in this old-growth stand, which contained abundant advanced reproduction, produced little reduction in humus depth. Litter depths on the selectively cut plot do not vary significantly from those on the uncut area, but those on the clear-cut area are nearly 3/4 inch less than those on the uncut area.

Cutting in the even-aged stand (Plots 4, 5 and 6) showed greater differences. Litter depths on the plot that received the 40 percent thinning did not vary significantly from the depths on the uncut plot. Litter depths on the clear-cut plot averaged nearly ½ inch less than those on the uncut plot. Humus depths on the plot that received the 40 percent thinning averaged nearly 3/4 inch less than those on the uncut plot. Humus depths on the clear-cut plot averaged about 0.8 inch less than those on the uncut plot.

These data indicate that repeated clear-cutting of hardwood stands will very definitely result in great reductions of litter and humus depths. Measurements made elsewhere in the Connecticut River watershed indicate that humus deterioration following extreme cutting might be much greater than indicated on the present plots if larger areas were involved. Here is one way in which method of timber cutting is highly important in regulating water yield from a watershed.

Rainfall Interception

Interception of rainfall by vegetation is one of the factors that must be evaluated in determining the water economy of a watershed. Measurements of interception have now been carried out on the Dilldown Watershed of the Delaware-Lehigh Experimental Forest throughout two summer-fall periods. These measurements are designed to determine the amount of rainfall that is intercepted by the extensive areas of scrub oak and also by the limited area of high forest found along the stream channel. The amount of interception, after correction for stemflow, has been found to correlate strongly with size of individual storms.

Comparison of the data for the scrub oak areas with that of the high forest sections indicate that although more rainfall penetrates the canopy of the high forest than that of the scrub oak, stemflow for the high forest is considerably less than that for the scrub oak.

Erosion From Skid Roads

Logging operations in steep, rugged terrain such as that found in the mountains of West Virginia must be carried on with great care to insure that watershed values will not be impaired.

One of the important considerations in this regard is the location, construction, and after-logging care of logging trails and roads.

Studies have been started on the Fernow Experimental Forest to provide information for the development of standards for locating, constructing, and treating logging skid roads. Although these studies are on a small scale and have been carried on for only a short period of time, the results to date are worthy of note.

Two skid roads were selected for comparative purposes. On one water bars were constructed at 2-chain intervals to prevent the build-up of surface runoff on the road. The second road received no special treatment. After logging operations had been completed, a series of permanent cross-section profiles were established on each road. The evaluation of soil loss due to erosion was made by periodic re-measurement of these profiles. The following table gives the results for three 3-month periods after logging:

Average soil loss per 100 linear feet of skid road

Period	Road with bars	Road without bars
	Cubic feet	Cubic feet
After logging		
March - May 1951	-55	-129
June - Aug.1951	-50	+ 10
Sept. - Nov.1951	-11	- 40

The data in this table point to two conclusions. First during the March-May period, erosion from the road without water bars was slightly more than twice that from the road with bars. This shows definitely that erosion from skid roads can be reduced by preventing the accumulation of water running down the road. But the period June-August shows more erosion from the road with water bars.

The reason for this reversal was determined by examination of the two roads. The road with no water bars had, for some as yet unexplained reason, developed a good cover of weeds, herbaceous species, and grasses while the road with water bars developed only a scanty and spotty ground cover. The apparent gain in soil on the road without water bars is due to deposition on the measured sections of material washed from adjacent parts of the road. After the growing period, when annual vegetation had died down, erosion relationships reversed again, as the September-November measurements show.

Results of this study to date may be summarized as follows:

- Surface drainage on logging skid roads must be broken up by frequent water bars to prevent the formation of eroding flows.

- The early development, after logging, of a permanent vegetative cover on these areas is probably the most important element in keeping erosion at a tolerable level.

FLOOD-CONTROL SURVEYS

Integrated river-basin planning is not a new concept. The need for such planning has been recognized for some years. The Tennessee Valley Authority and the Missouri River and Columbia River projects are milestones in the development of integrated planning. To the Northeast, however, such comprehensive planning is new.

Recognizing the need for integrated natural-resource planning, the President by executive order in 1950 instructed the Departments of Army, Agriculture, Interior and Commerce, the Federal Security Agency, and the Federal Power Commission to set up an inter-agency committee to carry out a comprehensive survey of the river basins of New England and New York. The instructions also provided for participation by the six

New England States and New York. This committee has been organized and during 1951 held frequent meetings and several hearings on the resource survey.

The comprehensive New England-New York survey and the companion Arkansas-White-Red survey are not analogous in the approach to river basin planning to that of the earlier projects. The TVA was established as a single agency to carry out comprehensive planning and operations in the Tennessee Valley. In the Missouri and Columbia River Basins, where comprehensive planning for large structures had already been developed, surveys were designed to add to such plans the projects and plans of other interested Federal and state agencies in order to cover more completely the field of soil and water resource planning. In the New England-New York and Arkansas-White-Red Basins the surveys are to be carried on as integrated Federal-State projects with consultation and coordination all along the way. It is in this respect that these two newest surveys differ from previous projects.

The New England-New York area included in the survey covers all the watersheds in the six New England States, and, in New York State the basins of the Hudson River and all rivers draining into the Great Lakes and the St. Lawrence River. The total land area to be surveyed is approximately 100,000 square miles. It includes 14 major watersheds and innumerable smaller drainages flowing directly into the Atlantic Ocean, Lake Ontario, Lake Erie, and the St. Lawrence River.

The flood-control survey work of the Station in 1951 was directed mainly to participation in certain phases of this comprehensive study--principally those in connection with flood control and land-use management, with major emphasis on the forestry aspects.

During the past year work has been completed on the inventory of present land use and condition. Flood-damages, particularly agricultural damages, have been surveyed for all watersheds except the Hudson and Champlain.

A compilation of all known local flood-damage centers was made with the assistance of state officials, Soil Conservation Districts, PMA County Committees, and the Corps of Engineers. This resulted in a list of 825 locations where flood problems were considered particularly important. A reconnaissance survey of all these areas was made by a joint team from Agriculture and the Corps of Engineers. A report on each location is being prepared indicating those that

warrant further and more intensive study to determine whether remedial measures can be justified. Reports on local damage centers in all the Maine Rivers and the Merrimack River have been completed.

To provide a basis for hydrologic analysis, 15 small watersheds, on which stream-flow gaging stations have been maintained, were selected as samples. Basic data on present land use and condition, future land use and management after installation of a flood-control program, stream-flow and precipitation data have been collected on all these sample watersheds. Analyses have been started to determine reductions in runoff and erosion on nine of the above watersheds; these analyses are about 50 percent completed.

Other work of the division was limited to revisions of watershed reports. Two of these reports were completed and forwarded to Washington. Four other reports are in various stages of completeion.

Status Of Surveys, End Of 1951

Surveys of the Forest Service, Soil Conservation Service cooperating, on the following watersheds:

Salt (Ky.).--Following review and comment by all agencies, final draft being prepared.

Merrimack (N. H. and Mass.)--Review draft completed and circulated.

Allegheny (Pa. - N. Y.).--Review draft in preparation.

Surveys by the Soil Conservation Service, Forest Service cooperating, on the following watersheds:

Youghiogheny (Pa.-Md.-W. Va.).--Report completed and forwarded to Washington.

Roanoke (Va.-N. C.).--Report completed and forwarded to Washington.

Lower Susquehanna (Pa.-Md.).--Review draft in preparation.

Joint surveys by the Forest Service and the Soil Conservation Service:

New England-New York Survey (Maine, N. H., Vt., Mass., Conn., R.I., New York).--Land-use inventory completed. Damage survey 65 percent complete. Reconnaissance survey of local damage centers completed. Hydrologic analysis under way on nine sample watersheds.

THE FOREST SURVEY

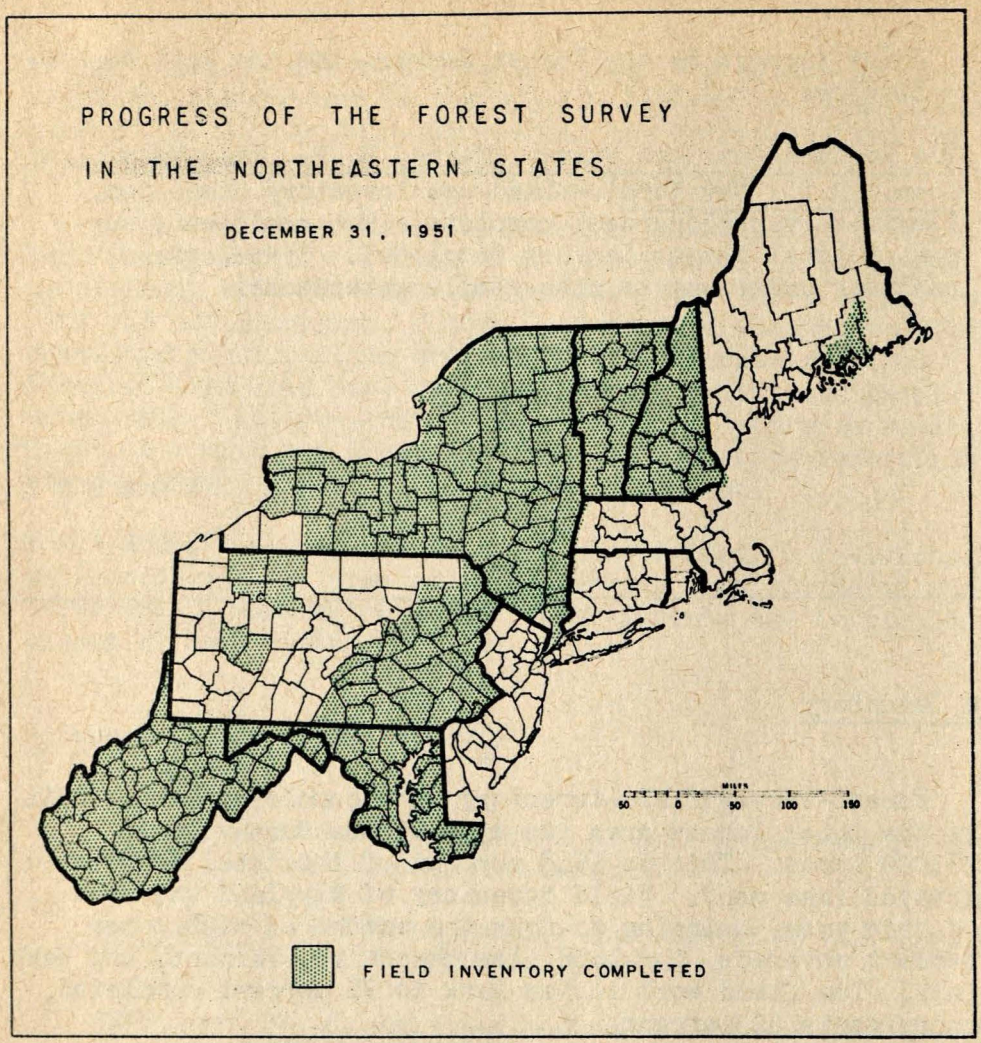
Field Inventory

Forest-survey field-inventory work completed during 1951 brings the total forest area surveyed in the Northeast to 40,827,000 acres. This is 55.8 percent of the total area to be surveyed (see map). Field inventory of Maryland was completed this year, bringing to four the number of states now 100 percent covered: Maryland, New Hampshire, Vermont, and West Virginia. The field work in New York is 91 percent completed, in Pennsylvania 42 percent.

Type-mapping has been kept nearly current, and all areas surveyed will be type-mapped before extensive field work in other areas is undertaken in 1952.

Growth

Growth computations are nearly complete for West Virginia. Meanwhile we are testing the efficiency of the method we use for determining growth, with the hope of finding a more simple, yet efficient method.



More than half of the forest area in the Northeast has been inventoried. The forest survey work has been completed in four states.

Commodity Drain

New York State.--With the exception of approximately 15 follow-up contacts with pulp mills and larger sawmills, all field work to determine commodity production has been completed in New York. Office summaries were made for fuelwood and fence-post production.

West Virginia.--Office computations on wood utilization were started and at year's end were approximately 40 percent complete.

Maryland.--Field studies were completed for wood utilization. Office computations to determine commodity production of all items except pulpwood were completed.

Reports and Special Studies

Both the final (analytical) report for New Hampshire and the preliminary state statistical report for Vermont have been reviewed, and final drafts are being prepared. Compilations and tables for the preliminary state statistical report for West Virginia are almost completed.

Preliminary tables of forest area and timber volumes have been prepared for three forest districts in New York, for a group of nine counties in eastern Pennsylvania, and for central Maryland.

Except for New Hampshire, all volumes have been or are being revised in line with log- and tree-quality specifications. Subgrade material is no longer included in sawlog volumes. Primary growing stock is now limited to the cubic volume of present and potential sawlog material.

In last year's annual report we told of initiating a study to determine the feasibility of estimating growth and drain by remeasuring sample field-survey plots. We also proposed to use volume classes based entirely on cubic-foot volume in our photo interpretation. This study has been completed with the following results:

- For estimating growth through remeasured plots, use of individual tree data on growth reduced the number of plots required. This reduction was not great enough to offset cost when all trees on the plot were identified. The most efficient procedure seems to be to identify permanently a subsample of the individual trees.

- Studies were made on the Eastern Shore of Maryland to find out if drain can be determined by comparing sets of aerial photographs taken in different years. The results were very promising. The method will be tested further in Connecticut,

Massachusetts, and Rhode Island. If the method proves to work well, it may be adopted as standard procedure.

- Photo interpretation using volume classes was shown to be more efficient than that using stand-size classes. We estimate it will reduce the number of ground plots required by about 15 percent.

FOREST ECONOMICS

In addition to the forest survey, which is the major project of the Station's Division of Forest Economics, a number of other investigations were undertaken during 1951:

Economics Of Forest Management

There has been a serious lag in applying forestry knowledge to the region's forest resource. In general, small forest owners have not been convinced that they can make money by practicing forestry. This is partly because the owner has no basis upon which to estimate his costs and returns from different courses of action.

The Station has been cooperating with Harvard University in an analysis of the small forest owner's economic problems. A thorough search has been made for existing forest-management records in New England. Although many such records were located, they are not complete or detailed, and cannot be used to show how physical output (logs and bolts harvested plus growth of standing timber) varies with physical input (labor, materials, equipment, and supervision) under different management methods.

We feel that another approach is needed. During 1951 a project aimed at developing the research methods needed to study the economic problems of the small forest owner was started.

Marketing Forest Products

The Northeast continually uses large numbers of wood poles and piling. However, northeastern forests supply but a small part of the regional demand. To find out how the pole and piling markets operate, a market survey was undertaken. About 80 percent of the field work was complete by the end of 1951. Other marketing research included completion of a forest-products marketing guide for forest owners of the Monocacy River watershed of Maryland and Pennsylvania.

Two test-demonstrations of the application of hardwood log grades to Vermont saw timber were completed. A hardwood log-grade scaling stick was developed as a training aid and is now being tested by the Vermont Forest Service. The Station continued to cooperate with various agricultural experiment stations in planning joint regional studies of forest-products marketing in the Northeast.

Other Economic Studies

The 1950 annual report gave the background of a comprehensive survey of the resources of New England and New York. To assist this survey, preliminary studies were made of receipts and shipments of forest products by rail and water, and of electric-power requirements of the forest-based industries in these states.

In 1949 the Station published reports based on 1948 examinations of the fire-damaged forests of southwestern Maine. In the fall of 1951, these lands were re-examined to determine what changes have taken place in the intervening 3 years. These data are being analyzed.

The new forest yield tax law in New Hampshire has aroused interest throughout the Northeast. While it is still too early to say how the law will influence forest practices, preliminary comparison of the new yield tax with the old property tax, using six farm forests as examples, indicates that the new tax favors more intensive forest management.

Preparation of a looseleaf handbook of forest-economic information for the Northeast was started.

Log Grades And Timber Quality

Following up the start made in previous years, the Station continued to explore the problems involved in developing and promoting a standardized system of timber classification and quality appraisal.

In cooperation with the Vermont Forest Service, studies were made at four hardwood mills to ascertain the applicability of a grading system developed from previous work of the Forest Products Laboratory. These studies showed that the system gave a good segregation of values among the different grades of logs. They also indicated the production variables introduced into milling costs by factors other than size, such as unsoundness, crookedness, and general prevalence of defect.

The Station held five 3-day training schools to bring the latest technical information about log grading to key men in the various agencies and industries that are interested in better wood utilization. Total attendance was more than 150. The following were represented at the schools: Two lumber companies; one pulp company; a bobbin company; two veneer companies; students and faculty of four universities; the Extension Services of Virginia and North Carolina; Bent Creek Experimental Forest, North Carolina; Tennessee Valley Authority; New York State Tax Inquiry staff; Ohio State Forest Service; U. S. Forest Service, Regions 7 and 8; the Central, Southeastern, and Northeastern Forest Experiment Stations; and the staffs of seven National Forests.

The Station also took part in several log-grading demonstrations during the year. These demonstrations were mainly for sawmill men. One was held in the Berkshires under the auspices of the Massachusetts Extension Service; two others were held in Vermont under the direction of the Vermont Forest Service. In all, more than 100 sawmill men attended.

Other activities of the Station in log grading included a refresher clinic for the technical staff of the Allegheny National Forest, lectures before students of silviculture, participation in the Timber Engineering Company's school on

Milpak, and tape-recorded broadcasts in collaboration with the New York State College of Forestry radio program.

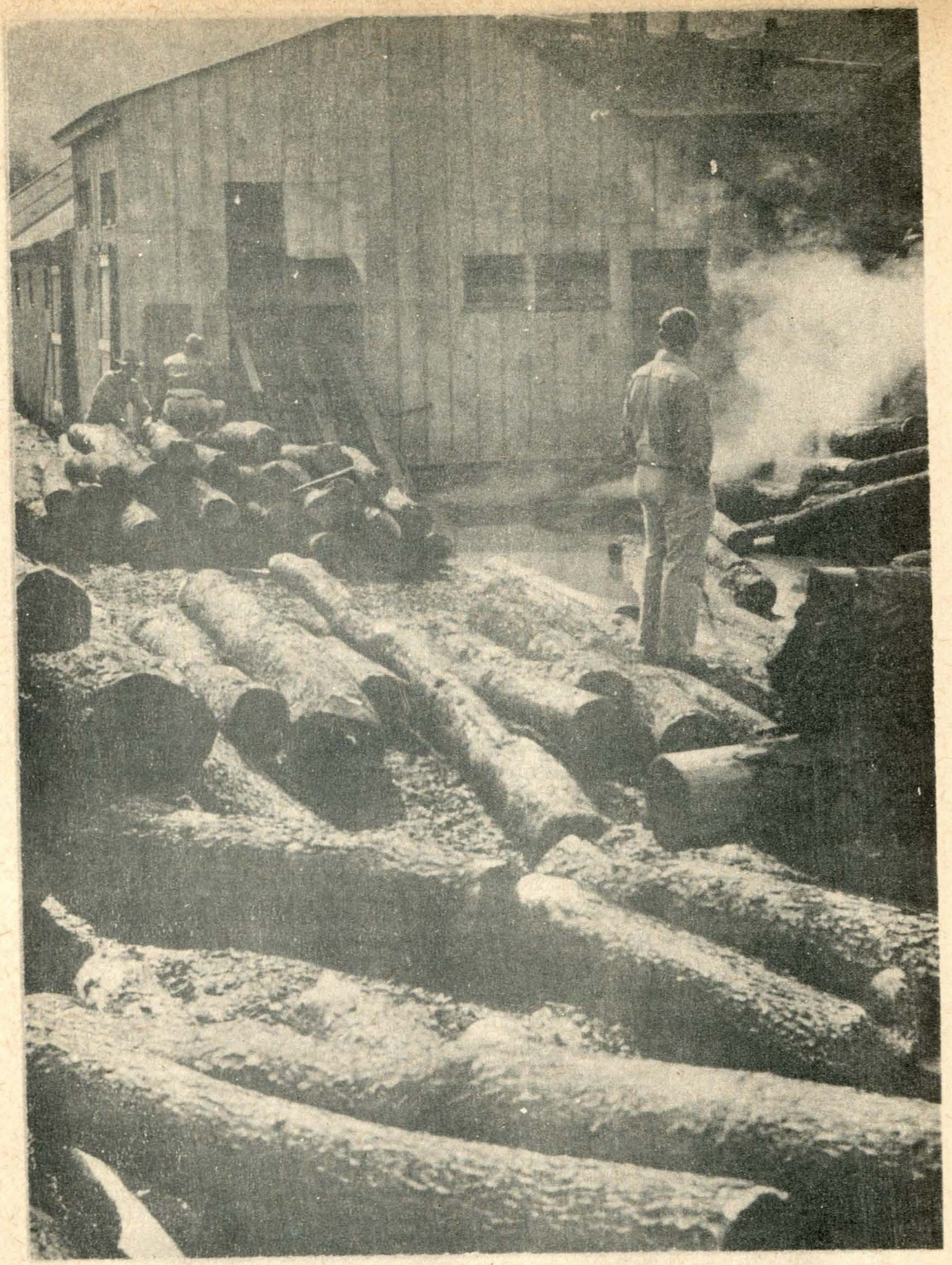
The extent to which the log-grading system has been put to practical use is encouraging. The Vermont Forest Service, following a plan prepared by the Station, made a qualitative survey of the timber in Vermont. The New York State Tax Inquiry, which is studying taxation problems of the public lands in the Adirondacks and Catskills, added a special timber-quality section to its forest-survey organization; its field crews were trained by the Station. One large pulp company, which is beginning a program of integrated utilization, has used the log-grading system as a basis for selling hardwood logs to a furniture factory. And the New York State College of Forestry, in carrying on a study of poor-quality hardwood areas, has used the system for classifying forest stands as well as for segregating the products harvested for detailed study.

As a result of the growing and widespread interest in log grades, the Forest Products Laboratory held a conference on hardwood log grading to work out details for an expanded research program to refine the system and fill in the gaps, particularly in regard to the veneer, structural, and local-use logs from the tree and the sawbolt portion of the remainder. A new concept was developed at this conference. This was the idea of formulating a master research plan with detailed working instructions for studies on all parts of the problem. These instructions, the basis for a coordinated series of cooperative studies, will be made available to any agency or industry that is interested in doing research in this field.

Logging And Milling

Most of the research by the Station in logging and milling during the year was confined to defense projects. A study of the Northeastern veneer industry was made early in the year. Later a comprehensive study of the equipment, manpower, and supply needs of wood-using industries was made for the National Production Authority.

The first edition of the Northeastern Loggers' Handbook was pretty well exhausted by the heavy demands from all over the United States. A movement was started to translate the Handbook into Japanese. Based on many of the ideas in this booklet, a scenario prepared by the Station was used in making a movie on better methods of logging. The "shooting" was done



A noteworthy example of good utilization. These black cherry logs, cut in a thinning operation in the Allegheny National Forest, are generally small and crooked. By using equipment adapted for small logs and bolts the operator recovers high-quality furniture dimension stock.

by the Division of Information of the Department of Agriculture, with the Station providing technical advice.

A logging operation connected with a timber sale on the Allegheny National Forest is noteworthy as an example of progress in utilization. A high percentage of the timber volume in this sale is black cherry of sublog size. The timber, cut in a thinning operation, is hauled in tree-lengths to a special small mill. These long pieces are, in the main, rather crooked. At the mill entrance, an electric chain saw is used to cut straight, short, random-length bolts from the logs. In the mill, which has a Ricker bolter, a straight line rip saw, a cut-off saw, and an automatic length sorter, the bolts are cut into 1-inch dimension stock. Widths are random and lengths range from 12-inches to 36-inches, in 3-inch multiples. From the sorter bins the green dimension is stickered on lift-truck pallets and bound with steel strapping. The loaded pallets are put in the yard for preliminary air drying. Later, still strapped in pallets, the wood is kiln dried; this operation is made possible by machine loading. It is estimated that the operator recovers 90 percent of the resulting Doyle scale in dimension stock.

Another interesting operation is in Massachusetts, where the operator of a box factory has installed an Esterer round-log gang saw. This machine is operating satisfactorily, according to the operator, on crooked white pine, hemlock, and white birch logs. 4/4 lumber is cut off the outside of the log and 8/4 from the center. As with most gang saws, a particular advantage lies in the accuracy of the sawing.

To promote better utilization of beech, the Northeastern Technical Committee on Beech, composed of representatives of 18 forestry agencies, has for several years been developing a project that calls for the preparation of a series of 23 papers in which will be presented the best available information about this species. The first of the series, "Some Physical and Mechanical Properties of American Beech", by Benson Paul and John Drow, of the Forest Products Laboratory, was published this year. Five others are being readied for publication and the remainder are in various stages of completion.

Seasoning

An important event in the seasoning field was the publication, in February, of a report by O. W. Torgeson of the Forest

Products Laboratory entitled, "Schedules for the Kiln Drying of Wood" (Report No. D1791). This report contains information that will enable kiln operators to develop much more rapid and safe schedules than it has been possible to develop before. This means not only a saving in material, but a tremendous saving in time, which in turn is equivalent to an increase in kiln capacity. One plant, using these schedules, reported a 50-percent reduction in drying time; another reported a 30-percent increase in output.

A big job is to get these schedules into the hands of all Northeastern kiln operators, and to study the results of their application. To do this, the Station continues to work with the Keystone, Northeastern, and New England Dry Kiln Clubs. Each of these clubs held two meetings during the year and at these meetings Laboratory technicians presented the kiln-schedule information.

Sponsored by the New England Dry Kiln Club, the Forestry Department of the University of Massachusetts, and the Station, the Laboratory held a 1-week clinic on the whole subject of kiln drying at the University of Massachusetts, Amherst. Fifteen students from industries throughout the Northeastern States attended the clinic. Arrangements were also made for Forest Products Laboratory technicians to participate in the annual dry-kiln course offered by the New York State College of Forestry, Syracuse, and to present information on the new drying schedules at the annual meeting of the Vermont Bureau of Industrial Research at Northfield, Vt.

The Station and technicians from the Laboratory visited a number of industrial plants (including Springfield Armory, Springfield, Mass.) and discussed kiln-drying problems. They investigated two new and much publicized developments in dry kilns. These were the Drylator, which uses very high temperature and extreme air velocity, and the wood electro-kiln, which uses a combination of conventional drying and high-frequency electric energy.

A survey of the mechanical handling of lumber made by the Forest Products Laboratory and the Station, in 1949, indicated a need for research into lumber-piling methods, particularly as related to the use of mechanical devices. Study of this problem was begun this year. The Station arranged for and participated in a cooperative experiment by a Philadelphia firm and the Forest Products Laboratory to study not only the effect of pile variations on seasoning, but also the effect of steaming before seasoning. For many years the company held lumber

in its yard for a year before fabrication. The first phase of the experiment showed that lumber put into piles in July was ready for manufacture in October. In this experiment electrical instruments are used extensively to get daily information on drying capacities and drying rates.

Charcoal

The charcoal business in the Northeast, both domestic and industrial, was very good during the year. Most producers reported demand in excess of supply. The Northeastern industry comprises a number of large plants in Pennsylvania and New York (which formerly produced a variety of wood chemicals but which now make charcoal exclusively), a number of kilns of the Connecticut type and a few metal kilns of the Black Rock type.

Last year a new development was introduced--the Mellman continuous process. This is essentially a large retort into the top of which wood is introduced and from the bottom of which charcoal drops into cans. Five untis of these were installed at two points, a battery of two at Tupper Lake, N. Y., and a battery of three at Speculator, N. Y. By late fall operations of these units had not yet been shaken down to a point where they were in successful commercial operation.

General

By correspondence, personal visits, and by referring queries to the Forest Products Laboratory, a large number of inquiries from timberland owners and wood-industry operators on a great variety of subjects were answered.

A member of the Station's Forest Utilization Service is an active member of the Northeastern Wood Utilization Council. Station personnel participated in a major way in the activities of the Forest Products Research Society by presenting papers, acting as members of the Regional Advisory Board, and serving on the committee in charge of the 1951 national meeting and logging equipment show, which was held in Philadelphia in May.

Working on defense problems, the Forest Utilization Service cooperated with the Forest Products Laboratory in studies of wood-use in military establishments, and supervised Station participation in a survey of equipment-manpower supplies.

Barraclough, Solon, and Gould, Ernst M., Jr.
1951. A PRELIMINARY APPRAISAL OF NEW HAMPSHIRE'S FOREST-YIELD TAX. Northeast. Forest Expt. Sta. Paper 45. 26 pp. Upper Darby, Pa.

Studying the effect of New Hampshire's forest-yield tax on sample farm forests, the authors calculate that forest owners who employ the better standards of forest practice will, in the long run, gain financially under the new tax system. "The new tax will not certainly solve New Hampshire's forest problem; its solution must come gradually through many different approaches. The new tax does, however, enhance the opportunities for forest management as a profitable enterprise."

Bethlahmy, Nedavia.
1951. AN ALINEMENT CHART FOR USE WITH THE FIBERGLAS SOIL-MOISTURE INSTRUMENT. Soil Sci. 71: 377-380, illus.

Description of an alinement chart used to shortcut the computations involved in computing soil moisture from resistance readings obtained by the so-called Colman meter. Put to practical use at the Delaware-Lehigh Experimental Forest, the alinement chart has saved considerable time.

1951. DISTANT EARTHQUAKES AFFECT LOCAL GROUND-WATER LEVELS. Northeast. Forest Expt. Sta. Northeast. Res. Note 9: 1-3. Upper Darby, Pa.

Ground-water levels in deep wells at the Delaware-Lehigh Experimental Forest in eastern Pennsylvania were observed to oscillate at times when earthquakes were reported in distant parts of the world. No pattern or trend has been observed. Results of distant earthquakes on these ground-water levels are being recorded and studied.

Bickford, C. Allen.
1951. FORM-CLASS VOLUME TABLES FOR ESTIMATING BOARD-FOOT CONTENT OF NORTHERN CONIFERS. Northeast. Forest Expt. Sta. Paper 38. 33 pp., illus. Upper Darby, Pa.

A handbook containing volume tables for form classes 65 to 86. The tables are based on Girard form class definition

of diameter inside bark at top of first log, using measured data from Maine pines as the basis for upper-log taper. The tables were prepared because the northern conifers taper more than the trees Mesavage and Girard based their form-class tables on, and adjusting the Mesavage-Girard tables for northern conifers proved to be impractical.

(Curry, John R.)
1951. PRINCIPLES OF FOREST MANAGEMENT.
Forest Farmer (Manual) 10 (5):13-17, illus.

A broad outline for forest management of southern timber lands. The author discusses growing stock, sustained yield, management plans, cutting operations, stand improvement, forest-management systems, silvicultural systems, and practical application of forest-management principles by small forest-land owners.

Doverspike, George E., and Camp, Harry W., Jr.
1951. FOUR TEST-DEMONSTRATIONS OF HARDWOOD LOG GRADES IN THE NORTHEAST. Northeast. Forest Expt. Sta. Paper 42. 19 pp., illus. Upper Darby, Pa.

The hardwood log-grading system developed by the U. S. Forest Products Laboratory is described and illustrated. Four test-demonstrations were made by running graded logs through mills and comparing the lumber-grade yield from the different log grades. Tests were made at a Pennsylvania sawmill, a West Virginia sawmill, a Maine handle plant, and a Maine dowel mill. The results demonstrated clearly that both the buyer and seller of logs can profit through use of log-quality standards.

---------- Rettie, James C., and Camp, Harry W., Jr.
1951. TIMBER MARKETS AND MARKETING IN THE MONOCACY RIVER WATERSHED OF MARYLAND AND PENNSYLVANIA. Northeast. Forest Expt. Sta. Paper 41. 17 pp., illus. Upper Darby, Pa.

In the Monocacy River watershed--as generally elsewhere in the country--standard grades and marketing practices for timber products have not been put into common practice. Usually timber is sold on a lump-sum basis here, and the seller has no way of knowing if he is getting a fair price for his timber. The authors describe log grades as one approach to fair prices. They urge small forest owners to use the services of state forestry agencies. A directory of timber buyers, and specifications for various products, is included.

Fenton, R. H.
1951. UNUSUAL CAUSE OF DEATH IN RED PINE PLANTATION. Northeast. Forest Expt. Sta. Northeast. Res. Note 2: 1. Upper Darby, Pa.

Death of apparently healthy trees in a plantation in Connecticut was traced to zinc chloride used in sap-stream preservative treatment of poles cut in thinnings.

Ferguson, Roland H.
1951. WHO LIKES SQUARE ROOTS? Jour. Forestry 49: 653.

Describes a simple method of extracting square roots on an ordinary calculating machine, to a large number of significant digits.

Gedney, D. R., and McConkey, T. W.
1951. 1-MAN CHAIN SAW MAY SAVE MANPOWER IN LOGGING WHITE PINE. Northeast. Forest Expt. Sta. Northeast. Research Note 2: 2-3. Upper Darby, Pa.

Production records from cuttings in the Massabesic Experimental Forest in Maine suggest that 1½ man-hours per 1,000 board feet can be saved in felling, limbing, and bucking by use of 1-man chain saws instead of 2-man chain saws.

Hough, A. F.
1951. TREE ROOTS. Pa. Forests 36 (346): 22-26, illus.

A description of the root system of a tree, how it functions, and how it affects--and is affected by--the soil. Sprouting of some species is described. The author points out the important function of tree roots in holding the soil in place and, by increasing the porosity of the soil, in giving forest soils the ability to absorb and store water.

Jensen, Victor S., and Wilson, Robert W., Jr.
1951. MOWING OF NORTHERN HARDWOOD REPRODUCTION NOT PROFITABLE. Northeast. Forest Expt. Sta. Northeast Research Note 3. 4 pp. Upper Darby, Pa.

Study of plots treated 16 years ago on the Green Mountain National Forest bear out the value of girdling, but the gain from mowing does not seem great enough to justify mowing.

Little, Silas.

1951. PRESCRIBED BURNING IN SOUTH JERSEY WOODLANDS. N. J. Agr. Col. Ext. Leaflet 65. 4 pp.

A leaflet telling what prescribed burning is, and why, where, when, and how it is used. Probable costs are indicated (5 cents to 40 cents per acre). The need for an approved plan, a permit, and cooperation of the State Forest Fire Service are emphasized.

1951. OBSERVATIONS ON THE MINOR VEGETATION OF THE PINE BARREN SWAMPS IN SOUTHERN NEW JERSEY. Torrey Bot. Club Bul. 78 (2): 153-160.

The vegetation was studied by quadrat samples on 16 areas in the swamps of the New Jersey pine region, on sites both formerly cultivated and never cultivated. The areas had stands principally of whitecedar, swamp hardwoods, or a mixture of these. The article lists 124 species or varieties of nonarborescent plants found: shrubs, vines and subshrubs, herbs, pteridophytes, liverworts, mosses, and lichens.

---------- and others.

1951. REPORT OF COMMITTEE ON FOREST MANAGEMENT, ALLEGHENY SECTION, SOCIETY OF AMERICAN FORESTERS, FEBRUARY 1951. Jour. Forestry 49: 731-734.

---------- and Somes, H. A.

1951. DEER BROWSING IN NEW JERSEY HANDICAPS PINE SEEDLINGS. Northeast. Forest Expt. Sta. Northeast. Research Note 2: 3-4. Upper Darby, Pa.

Browsing by deer did not increase mortality, but did hold back height growth of seedling pines. This handicaps the pines in their fight for survival against the less-valuable competing hardwoods.

---------- and Somes, H. A.

1951. AGE, ORIGIN, AND CROWN INJURIES AFFECT GROWTH OF SOUTH JERSEY PINES. Northeast. Forest Expt. Sta. Northeast. Res. Note 8. 4 pp. Upper Darby, Pa.

Studies of a fire-damaged oak-pine stand that was later treated with prescribed burns and cutting of oaks indicate that cuttings in such stands in southern New Jersey should usually favor the establishment of vigorously growing young pine reproduction. Cuttings should not attempt to stimulate growth of overstory trees, and long-suppressed pine reproduction can be ignored.

Little, S., and Somes, H. A.
1951. NO EXCEPTIONAL VIGOR FOUND IN HYBRID PINES TESTED. Northeast. Forest Expt. Sta. Northeast. Res. Note 10. 4 pp. Upper Darby, Pa.

Report on survival and growth of pitch x loblolly and shortleaf x pitch pine hybrids in New Jersey and Maryland 6 years after planting. None of the hybrids was exceptional. The best were pitch x loblolly pines, which have well-developed, fibrous root systems that enabled them to survive better than the others; but they are developing into trees that do not have as good timber form as ordinary loblolly.

Lockard, C. R.
1951. HARDWOOD LOG GRADING--A PHASE OF QUALITY CONTROL. South. Lumberman 182 (2279): 84, 86, 88, 90.

Describes the importance of quality to timber growers and users, the general requirements for a system of log-grading, and the system developed by the Forest Products Laboratory. Widespread use of such a system would improve the growing of timber and the utilization of it, and would improve the whole process of marketing logs. It would put the seller in a better bargaining position and would give the buyer a means of figuring accurately the value he can get from logs he buys.

1951. LOG GRADING PROBLEMS. Wood 6 (3): 24, 38, 40, 42, 45.

Appraising timber quality is important to timber growers and timber users, but little has been done to tackle the problems involved. The author describes the log-grading system developed by the Forest Products Laboratory and tells how it works. Use of the system can not only help timber growers and users; it can also help to upgrade timber in the woods. (Based on material presented at Forest Products Research Society meetings.)

McConkey, Thomas W., and Gedney, Donald R.
1951. A GUIDE FOR SALVAGING WHITE PINE INJURED BY FOREST FIRES. Northeast. Forest Expt. Sta. Northeast. Res. Note 11. 4 pp. Upper Darby, Pa.

From studies of fire-damaged trees on the Massabesic Experimental Forest in Maine, the authors offer some general guides on salvage priorities, based on degree of root injury and crown injury. They suggest 25 or more seed trees (more than 12 inches d.b.h. with only light root injury) per acre be left.

McGuire, John R.
1951. WHITE PINE RESEARCH IN MAINE.
Univ. Maine, Maine Forester 1951: 52-57.

Brief description of white pine research being carried on in Maine by the Northeastern Forest Experiment Station, Maine Forest Service, and Maine University Agricultural Experiment Station. Some details on the studies at the Northeastern Station's Massabesic Experimental Forest, including studies of damage from the 1947 forest fire and subsequent seeding tests.

---------- and Wray, Robert D.
1951. FOREST STATISTICS FOR NEW YORK FOREST DISTRICT NO. 1.
Northeast. Forest Expt. Sta. Forest Statistics Series: N. Y. No. 1. 21 pp. Upper Darby, Pa.

Report on forest survey inventory of Delaware, Otsego, and Schoharie Counties, New York. Brief descriptions of the area and survey methods, and tabular data on commercial forest area, net volume in live timber, sound wood volume in live cull trees, and average net volume per acre in live timber. Data are broken down by forest types, stand-size classes, and diameter classes. Saw-timber volumes in board feet, total volumes in cubic feet and cords.

McLintock, Thomas F.
1951. BUDWORM DAMAGE IN CANADA: SOME OBSERVATIONS ON MORTALITY. Northeast. Forest Expt. Sta. Northeast. Research Note 4: 1-2. Upper Darby, Pa.

Once trees started to die, mortality went up fast: from 0 in 1948 to 25% in 1949 to 48% in 1950. Stands on wet sites and having a large proportion of big old dominant fir trees should be cut first. Vigorous, fast-growing trees with large crowns are relatively good risks. Young fir stands under a protective hardwood canopy are less subject to damage.

1951. STUMP DIAMETER RELATED TO D.B.H. FOR SPRUCE-FIR REGION.
Northeast. Forest Expt. Sta. Northeast. Research Note 4: 2-4. Upper Darby, Pa.

Offers a d.b.h.-stump conversion table for the benefit of cutters, scalers, and inspectors who are used to thinking in terms of stump rather than d.b.h.

McLintock, Thomas F.
1951. STOCKING IN SPRUCE-FIR STANDS. Northeast. Forest Expt. Sta. Northeast. Res. Note 9: 4. Upper Darby, Pa.

The stocking of spruce and fir on four 300-acre tracts in northern Maine is reported. Measurements of these tracts in 1953-55 is expected to yield tentative information on the optimum stocking.

McQuilkin, W. E.
1951. WEED KILLERS OF LIMITED USE IN REFORESTING SCRUB OAK BARRENS. Northeast. Forest Expt. Sta. Northeast. Res. Note 6. 4 pp. Upper Darby, Pa.

The chemicals 2,4-D and 2,4,5-T applied as summer sprays at 0.6% concentration did not control scrub oak or its common associates. Ammate at 2 pounds per gallon killed or weakened scrub oak and associated species so planted seedlings have a chance to survive. But the treatment is expensive, and planting is difficult in the dead standing oak brush.

1951. BULLDOZER BETTER THAN POISONS FOR PREPARING SCRUB OAK PLANTING SITES. Northeast. Forest Expt. Sta. Northeast. Res. Note 7. 4 pp. Upper Darby, Pa.

Furrowing with a bulldozer effectively prepared planting sites in Pennsylvania scrub oak barrens so that seedlings should come through without need for later release cuttings. The treatment is not entirely satisfactory and further trials with different kinds of equipment are planned.

Northeastern Forest Experiment Station.
1951. ANNUAL REPORT 1950. Northeast. Forest Expt. Sta. 102 pp., illus. Upper Darby, Pa.

1951. SURVEY REPORT, CONNECTICUT RIVER WATERSHED, VERMONT, NEW HAMPSHIRE, MASSACHUSETTS, CONNECTICUT. Northeast. Forest Expt. Sta. 48 pp., illus.; appendix 88 pp. Upper Darby, Pa.

Final report on flood-control survey of the Connecticut River, with recommendations for a remedial land-use program. For administrative use only.

Northeastern Forest Experiment Station.
1951. TENTATIVE REPORT ON FLOOD CONTROL SURVEY OF THE MERRIMACK RIVER WATERSHED, NEW HAMPSHIRE AND MASSACHUSETTS. Northeast. Forest Expt. Sta. 44 pp., illus.; appendix 87 pp. Upper Darby, Pa.

A preliminary report on the findings of the flood-control survey of the Merrimack River watershed, with recommendations for a remedial land-use program. For review purposes only.

1951. TENTATIVE REPORT ON FLOOD CONTROL SURVEY OF THE SALT RIVER WATERSHED, KENTUCKY. Northeast. Forest Expt. Sta. 41 pp., illus.; appendix 89 pp. Upper Darby, Pa.

A preliminary report on the findings of the flood-control survey of the Salt River watershed, with recommendations for a remedial land-use program. For review purposes only.

Paul, Benson H., and Drow, John T.
1951. SOME PHYSICAL AND MECHANICAL PROPERTIES OF AMERICAN BEECH. Northeast. Tech. Com. on Util. of Beech and Northeast. Forest Expt. Sta., Beech Util. Ser 1. 17 pp., illus. Upper Darby, Pa.

First in a series of papers to promote utilization of American beech. Describes general characteristics, density, shrinkage, spiral grain, bending strength, compressive strength, stiffness, hardness, shock resistance, nail-holding power, and splitting. Qualities are compared with those of other woods in tabular and graph form. Beech compares well in all respects with comparable hardwoods such as maple and birch.

Potter, H. S., Weitzman, Sidney, and Trimble, George R., Jr.
1951. REFORESTATION OF STRIP-MINED LANDS IN WEST VIRGINIA. Northeast. Forest Expt. Sta. Paper 43. 28 pp., illus. Upper Darby, Pa.

Natural revegetation and study of the soils indicate that large parts of the strip-mined areas in West Virginia could be reforested. Limiting factors are soil acidity, physical composition of the soil, spoilage, compaction due to grading, slope, and drainage. Recommendations for reforestation are offered, including discussions of site examination, species to plant, planting stock, and planting methods.

Reigner, Irvin C.
1951. EROSION STUDIES ON THE SCHOHARIE WATERSHED, NEW YORK. Northeast. Forest Expt. Sta. Paper 44. 17 pp., illus. Upper Darby, Pa.

A cooperative study of erosion in Schoharie watershed was made in 1950, when drought had dropped water levels to record lows. The studies indicated that erosion is not serious in the watershed, and that sedimentation in the reservoir is not serious except at the intake to Shandaken Aqueduct. However, supplementary studies of land use in the watershed indicate the problems may become worse, and a thorough study of the watershed, with view to planning a land-use program, is recommended.

Rettie, James C.
1951. FORESTS AND YOU.
Pa. Forests 36: 82.

Pointing out our daily dependence on wood products (from railroad ties and mine timbers to toothpicks, whisky barrels, and cellophane), the author notes that the freight bill for timber products imported by Pennsylvania was more than $40 million in 1950. "We have a lot of good forest land in Pennsylvania. It would pay us well to grow more timber on it..."

---------- Doverspike, George E., and Banks, Wayne G.
1951. FOREST RESOURCES OF THE MONOCACY RIVER WATERSHED OF MARYLAND AND PENNSYLVANIA. Northeast. Forest Expt. Sta. Paper 40. 29 pp., illus. Upper Darby, Pa.

Report on a special study of the Monocacy River watershed, in cooperation with the Maryland Department of State Forests and Parks and the Monocacy River Watershed Council. Includes forest area, location, ownership, types, and condition; volume, growth, drain, and information on timber-based industries and income. A program is outlined for better forest management aimed at conserving the water resource as well as improving the timber resource.

Scheffer, Theodore C., and Zabel, Robert A.
1951. STORAGE OF BEECH LOGS AND BOLTS IN THE NORTHEAST. Northeast. Tech. Com. on Util. of Beech and Northeast. Forest Expt. Sta., Beech Util. Ser. 2. 13 pp., illus. Upper Darby, Pa.

Describes the causes of decay in beech logs during warm-weather storage. Methods to prevent loss include winter

cutting and prompt milling. Pond storage is effective indefinitely. Storage under wet hay has been used with good results. End coatings are recommended to prevent checking, but spraying with preservative solution to prevent fungus infection is not effective.

Schreiner, Ernst J.
1951. BREEDING POPLARS FOR DISEASE RESISTANCE.
Brooklyn Bot. Gard., Plants & Gardens 7: 140-143, illus.

Poplars are not physiologically short-lived trees (several examples of old trees are cited to show this), but many poplars die young because they are extremely susceptible to disease. Yet poplars are valuable because they grow fast. In the Station's tree-breeding work, attempts are being made to develop disease-resistant hybrid poplars.

1951. OF FOREST TREES AND HONEYBEES.
Pa. Forests 36 (346) 13-15, illus.

Describes the important part bees play in our agricultural economy by pollinating commercial fruit and seed crops. Although insect-pollinated trees in our forests probably do not depend for pollination on bees, these trees can be of great value to the beekeeper, providing bee pasture before and between the major field crops. Some of the trees that provide good bee pasture and are useful in honey-making are: maple, willow, honey locust, black locust, basswood, yellow-poplar, cucumbertree, sourwood, persimmon, catalpa, redbud, black cherry.

Simmons, Fred C.
1951. NORTHEASTERN LOGGERS' HANDBOOK.
U. S. Dept. Agr., Agr. Handbook 6. 160 pp., illus.

A handbook describing all tools, methods, and equipment--old as well as modern--used in logging in the Northeast. The handbook contains information on common tools and how to use them (ax, various saws, wedges, peavies, canthooks, pulp hooks, peeling tools); methods of felling, limbing, bucking, skidding, cable logging, loading, winter hauling, road construction, use of wire rope, logging trucks. Also a glossary of logging terms.

Simmons, Fred C.
1951. THE AX.
South. Lumberman 182 (2281): 76, 78, 80, 82, illus.

An excerpt from the Northeastern Loggers' Handbook (see above).

1951. BUCKING FOR INTEGRATED LOGGING.
Lumber Camp News 13 (8): 8.

Urges both large and small logging operators to cut up their tree-length logs with an eye to valuable veneer logs, sawlogs, and turning bolts instead of cutting everything into 4-foot pulpwood bolts.

1951. HARVESTING FUELWOOD IN STICK FORM.
Northeast. Wood Util. Council Bul. 35: 21-34, illus.

Cost of fuelwood, which always comes back into greater use during national emergencies, is high because of labor costs. But with the aid of modern mechanical equipment, the man-hour cost of producing fuelwood can be cut to one-third. The author describes some of the equipment that can be **used** and presents sample cases to show costs.

Somes, H. A.
1951. COST OF PRESCRIBED BURNING CONTINUES TO GO DOWN.
Northeast. Forest Expt. Sta. Northeast. Research Note 2: 4. Upper Darby, Pa.

Costs of prescribed burning were reduced from 24 cents per acre in the winter of 1946-47 to 13 cents in 1949-50. More extensive burning and increased experience of the crews are credited for the saving.

Storey, Herbert C.
1951. FOREST AND WATER RESEARCH PROJECT. DELAWARE-LEHIGH EXPERIMENTAL FOREST. Pa. Dept. Forests and Waters. 44 pp., illus. Harrisburg.

Detailed description of the cooperative forest and water research project carried on at the Delaware-Lehigh Experimental Forest, with detailed hydrologic data for 1949-50. Forest-management studies under way (scrub oak conversion) are described, and other studies planned are outlined.

Storey, Herbert C.
1951. A MILESTONE IN CONSERVATION...A NATIONAL WATER RESOURCES POLICY. Pa. Forests 36: 76-77, 80.

The report of The President's Water Resources Policy Commission is hailed as a milestone on the road to conservation of water resources. Quoting from the report, the author outlines the importance of water, the development of the National policy, and the basic principles it is founded on.

Trimble, George R., Jr., Hale, C. E., and Potter, H. S.
1951. EFFECT OF SOIL AND COVER CONDITIONS ON SOIL-WATER RELATIONSHIPS. Northeast. Forest Expt. Sta. Paper 39. 44 pp., illus. Upper Darby, Pa.

A study of soil samples from representative parts of the Allegheny River watershed was made in an attempt to find out how soil conditions and land use affect the movement and storage of water in the soil. Percolation rates, detention storage, retention storage, and transmission rates and capacities were analyzed in relation to soil characteristics and land use. The results showed that physical soil improvements resulting from better land-management practices are greatest in the upper soil horizons; but an improvement that increases the percolation rate and detention-storage capacity of any soil horizon increases the possibility of utilizing more fully the storage capacity of the horizons under it.

Westveld, Marinus.
1951. VEGETATION MAPPING AS A GUIDE TO BETTER SILVICULTURE. Ecology 32: 508-517, illus.

The climax forest is in harmony with its environment and is inherently healthy; the silviculturist should use climax type as a guide. The author explains how climax type for an area can be estimated from present forest cover, and how indicator plants can be used to determine climax type. He shows how site-type classification has been developed in the Northeast, and how the silviculturist can use maps of the forest vegetation as a practical guide to good silviculture.

Wright, Jonathan W.
1951. TREE-BREEDING TECHNIQUE: SOME EFFECTS OF CONTINUOUS BAGGING. Northeast. Forest Expt. Sta. Northeast. Research Note 5. 4 pp. Upper Darby, Pa.

Protective casings used to protect tree flowers from unwanted pollen during the breeding season were accidentally left on some trees. Usually the effect of this is injurious,

but some beneficial effects were found, especially with some pine species.

Weitzman, Sidney.
1951. PLANTING STRIP-MINE SPOIL BANKS.
Forest Farmer 11 (2):

Outlines species and methods of planting on strip-mine spoil banks in West Virginia.

AGRICULTURE--FOREST SERVICE--UPPER DARBY

Submitted But Not Yet Published

Bethlahmy, Nedavia.
A METHOD TO DETERMINE THE WATER CONTENT OF SOILS.
(Amer. Geophys. Union Trans.)

WHY DO PLANTS WILT IN COLD WEATHER?
(Ecology)

Bickford, C. A.
THE SAMPLING DESIGN USED IN THE FOREST SURVEY OF THE NORTHEAST. (Jour. Forestry)

Caporaso, A. P.
THE FOREST SURVEY IN PENNSYLVANIA.
(Pa. Forests)

Curry, John R., and Church, Thomas W., Jr.
OBSERVATIONS OF WINTER DRYING OF CONIFERS IN THE ADIRONDACKS. (Jour. Forestry)

Dill, Henry W.
AIRPHOTO INTERPRETATION IN LAND-USE INVENTORY AND PLANNING. (Jour. Soil and Water Conserv.)

Kidd, Walter J.
A SMALL-TREE DIAMETER GAGE.
(Jour. Forestry)

McQuilkin, W. E.
TREE PLANTING IN THE NORTHEASTERN STATES.
(U.S. Dept. Agr.)

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